ENV S 127 B - Advanced Environmental Education & Practicum

Maddi Conrad
Spring 2025

Environmental Education Project

"Integrating Environmental & Climate Change Education with Next Generation Science Standards (NGSS) in Classroom Settings: How can we as future teachers can become better prepared to teach about climate change"

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<u>Env S 127B - Environmental Education Project Proposal</u>

Group:

Maddi Conrad

Topic of Instruction:

Integrating Environmental & Climate Change Education with Next Generation Science Standards (NGSS) in Classroom Settings: How can we as future teachers can become better prepared to teach about climate change

Audience:

Club members & board from CalTeach Together @ UCSB (undergraduate students w/ interest in STEAM and env ed and in becoming teachers)

Locations of Instruction:

Classroom/s that CalTeach regularly meets in - ED 4211 & 4219

Courtyard outside of Education building

Summary of Lessons:

<u>Lesson 1</u> - The first lesson I will be teaching will be about how teachers can develop their own personal nature connection so that they can model environmentally conscious behavior for their students. Participants in this workshop will do an initial reflection and discussion on how they feel connected to the natural world, will do a sit spot activity, learn an overview of what environmental education is and what it entails, will create a mind map, will learn about their own roles as teachers, and will end with doing the sit spot again. The goal of this lesson is that participants will be able to explain their own connection to nature and the importance of nature connection for school-aged children, as well as be able to infer how to bring environmental education into a classroom setting through learning about examples of EE activities and principles. Participants should also feel more appreciative of their local environment and will feel more connected to nature.

<u>Lesson 2</u> - The second workshop session will be focused on how to bring climate science into the classroom and learning about how to teach climate change to school-aged children. To make sure all participants are on the same page, this workshop will begin with a mini-lecture on Next Generation Science Standards (NGSS) and an analysis of Assembly Bill 285, the new state law requiring climate change education in K-12 curriculum. This lesson will have participants reflect on why teachers should care about climate change, the role that teaching and education plays in addressing the climate crisis, and how to adapt teaching methods and content when it comes to having different students learn about climate change. Participants will be asked to research a

local climate change issue and will give a short presentation acting out as teachers for their age group of choice.

Lesson 3 - The final lesson will have participants integrate what they have learned about environmental education and climate science to create a lesson plan about coastal wetlands. They will be asked to incorporate NGSS as well as an EE activity discussed in previous workshops into a lesson plan about the coastal wetlands around Santa Barbara and/or in Southern California as a whole. This workshop will be mostly individual work time and participants will be expected to tailor their lesson to a specific grade level; they will also be expected to explain their reasoning behind why they chose to include or omit certain elements such as activities or content. The last part of this workshop will have participants reflect on their whole experience and will likely involve another journaling session and group discussion.

Summative Assessment Ideas:

To make sure that participants are meeting the objectives of this unit, they will be assessed in a variety of ways. The first lesson focuses on personal connection and utilizes journaling as well as group discussion; participants' performance will be evaluated based on their journal entries, answers to questions, reflections shared in group discussions, and contributions to the mind map creation. The second lesson will involve more independent research as well as group discussion and analysis; participants will be evaluated via their answers to questions, their participation in conversation, and by their demonstrated commitment to teaching about climate change via a series of modeling exercises (pretend to be teachers and teach us pretending to be specific age group about climate change topic of choice). The third and final lesson will involve participants designing their own environmental education lesson and they will be assessed based on how they incorporate NGSS and EE guidelines. They will also be expected to show competency in understanding the ways that climate change affects ecosystems, as well as how to teach their students of choice about heavy subjects like climate change.

Additional Information:

The lessons in this unit will function more as workshops and will only include three due to the time constraints and limited number of instructors and participants. The CalTeach Together Club does not currently have a strong attendance and it is highly variable how many people show up to scheduled meetings. Lessons 2 and 3 may be done back to back on the same day depending on scheduling and everyone's availability.

Lesson Plan For 2025 Environmental Education (EE) Unit

Title of Lesson: Developing Personal Nature Connection as Teachers

Instructors: me (Maddi)

Student/Audience Description: Club members & board from CalTeach Together @ UCSB (undergraduate students w/ interest in STEAM and env ed and in becoming teachers)

Amount of Time for the Lesson: Length of club meeting (usually ~45 min to an hour)

Management Considerations: Not set number of people, not all members come to every meeting

Materials: Journal packets for each student & for instructor to follow along with, slides for participants to follow & includes guiding questions & information

Cognitive Objectives: Participants will be able to explain their own connection to nature and the importance of nature connection for school-aged children. Participants will be able to infer how to bring environmental education into a classroom setting through learning about examples of EE activities and principles.

Affective Objectives: Participants will be more appreciative of their local environment and will feel more connected to nature.

Step-by-Step Procedures - 5E's *using instead of Natural Learning Cycle

Engage:

To begin the lesson, all participants will sit in a circle and we will go around and share our names and what we are feeling grateful for today. Next, the instructor will share a brief overview and roadmap of what the lesson and activities are going to look like; this all should take about 2 minutes.

Then to engage the curiosity of the participants, the instructor will ask them to think to themselves for about 2 minutes about how they feel connected to nature and to think of a story to share about a time they felt a deep connection to the natural world. The instructor will share a few examples of what nature connection can look like. The participants will also be encouraged to write their thoughts in the provided journals if that helps them to reflect better on their experiences. This activity will connect participants' prior experiences in nature to what we will be learning and discussing later on in the lesson.

Then, because this group will likely be around 3-6 people, we will come back all together to share our responses; this should take about 5 minutes.

Explore:

Next in our lesson, participants will explore their own thought process and personal nature connection via a sit spot activity. The instructor will ask participants to go outside of the classroom to the courtyard area by the Education building. Participants will be asked to sit

quietly without outside distractions such as phones or music, and will be told they may close their eyes. Participants will also be asked to think to themselves and jot down in their journals what they notice or what feelings come up as they are sitting outside. Some guiding questions for them to use in their journaling include:

What do you notice?

What do you hear? See? Smell? Feel?

What do you admire?

What astonished you?

What would you like to see again?

After about 5 minutes, the instructor will call participants back inside. Here, we will regroup and discuss how the activity went. Some guiding questions for this discussion include:

How did that activity feel for you?

Was it hard to do?

Did you find your mind wandering?

Why do you think I asked you to do this activity?

What would students get out of doing this activity? How would they benefit?

Explain:

Next to make sure everyone is on the same page, we will go into an overview of what environmental education is. The instructor will share a series of slides and go through a more traditional mini lecture style to explain to participants what EE consists of, what values it promotes, and why it is important.

First, however, the instructor should ask participants what prior knowledge they have of environmental education and if they could share how they would define it. This allows the instructor to gauge the working knowledge of the group as well as provides information for what their initial thoughts are about EE.

The instructor will use quotes from the North American Association of Environmental Education (NAEE) and the UNESCO Tbilisi Declaration to define environmental education and what it entails. Next, the 12 guiding principles of EE from the Tbilisi Declaration should be included to provide participants with an understanding that EE is a holistic & interdisciplinary field by providing them with the idea that it is a robust and well-thought out discipline, the same as language arts or math. This should all take about 10 minutes.

After the mind map activity described below, the instructor will go into more explanation about the role that teachers play in getting students to learn about environmental education. This section will explain how it is easy to teach environmental education but that it's better to live it and be a model for the behavior that participants as teachers want to see in students. Participants will also be informed about their legal responsibility to incorporate EE into their lessons, by

giving info on the Environmental Education Principles and Concepts, Next Generation Science Standards, and Assembly Bill 285.

We will also be discussing ways that can incorporate environmental education into existing curriculum and lesson plans for various subjects and grade levels. THis should take about another 10 minutes.

Elaborate:

Participants will then be asked to create a mind map on the whiteboard that relates to the prompt:

Why does environmental education matter in the classroom?

The instructor may also ask probing questions to try to get participants to say more and elaborate on certain answers; this will help participants make more connections and broaden their understanding of the complexity and interconnectedness of EE. This will allow students to apply what they have learned about EE.

Evaluate:

As a final activity, participants will be asked to redo the sit spot activity but this time to imagine themselves as a student of their choice, maybe the age they want to teach or one they have most experience with. This will take another 5 minutes. After calling everyone back in we will discuss how that activity felt different than the first one and use more guiding questions:

How did that feel differently this time?

Was it easier for you to sit quieter this time? Was it more difficult? Why or why not?

Is this activity something you could see yourself doing as a teacher? How would you modify it to fit into your lessons and curriculum?

As a final resource, the instructor will provide more examples for how to incorporate EE into classrooms and elicit participant ideas. Together participants and the instructor will come up with activities and topics that pertain to EE that can be incorporated into language arts, math, social studies, and science curricula. This ending section should take about 5 minutes/rest of hour period.

Assessment (that matches with the original Objectives)

During the workshop, I will evaluate the participants' engagement with the material, participation in group discussion and responses to question prompts. After this first workshop, I will look over the participant's journals and compare the two sit spot activities; in doing this I am looking for is that they are demonstrating increased engagement in the second activity and that they are incorporating what was learned during the lesson in their journaling

Explanation of How You Have Address ALL 4 Learners—Use 4MAT Theory to Explain

Type 1: Insight

This lesson addresses this learning style through reflecting on how participants personally value and connect with nature in their own lives and through discussion of how that connection can

show up in a teaching setting. Insight learners will appreciate learning about how to blend personal values with their professional lives as role models for school-aged children.

Type 2: Analytic

Analytic learners will appreciate the explanation of environmental education and the discussion of examples of EE activities. They will also enjoy learning about the benefits of EE in schools and how it has been shown to enhance students' learning and overall school experience.

Type 3: Common Sense

This lesson addresses this learning style via an explanation for why environmental education is important in the first place. Participants with this learning style will appreciate creating the mind map as it will show the practicality of applying EE in schools. They will also appreciate learning about ways to improve their own nature connection.

Type 4: Dynamic

Dynamic learners will appreciate the combination of the sit spot activities with group discussion. They will enjoy learning about themselves through journaling and reflecting individually and as a group how that activity made them feel. I think dynamic learners will also appreciate the discussion of how EE can look different depending on the teacher's own experiences with nature and how nature connection can take on many different forms

Developing Personal Nature Connection as Teachers

Env S 127B – Advanced EE & Practicum

Maddi Conrad

CalTeach Together @ UCSB

Intro & Acknowledgment

Today's workshop is my first lesson for my unit of instruction that I have chosen to teach for my class Env S 127B!

I have chosen to develop lesson plans based on teaching those interested in becoming educators (you all!) how to integrate environmental education and climate science with NGSS in more traditional classroom settings

I want to thank you all in advance for your time, focus, and participation in today's workshop.

Roadmap

1. Intros & Gratitude Circle
2. How do you feel connected to nature?
3. Sit Spot Activity #1
4. Overview of EE
5. Mind Map Activity
6. Teacher's as Role Models
7. Sit Spot Activity #2
8. Conclusion & Wrap Up

Intros & Gratitude

1. Name
2. What are you grateful for today? - can be anything, big, small or in-between

"Isn't just a pleasant feeling—being grateful can also support greater health, happiness, and wisdom in ourselves and our communities" https://www.mindful.org/the-science-of-gratitude/

Sit Spot #1

Take some time to sit outside, maybe close your eyes, and write in your journal:

What do you notice?

What do you hear? See? Smell? Feel?

What do you admire?

What astonished you?

What would you like to see again?

Wilderness Awareness School

Discussion

How did that activity feel for you?

Was it hard to do?

Did you find your mind wandering?

Why do you think I asked you to do this activity?

What would students get out of doing this activity? How would they benefit?

What is Environmental Education (EE)?

"Environmental education (EE) is a process that helps individuals, communities, and organizations learn more about the environment, and develop skills and understanding about how to address global challenges. It has the power to transform lives and society. It informs and inspires. It influences attitudes. It motivates action. EE is a key tool in expanding the environmental movement and creating healthier and more civically-engaged communities"
North American Association of Environmental Education (NAEE)

"constitute a comprehensive lifelong education, one responsive to changes in a rapidly changing world. It should prepare the individual for life through an understanding of the major problems of the contemporary world, and the provision of skills and attributes needed to play a productive role towards improving life and protecting the environment with due regard given to ethical values" UNESCO, 1977

Guiding Principles of EE

1. consider the environment in its totality—natural and built, technological and social (economic, political, cultural-historical, ethical, esthetic);
2. be a continuous lifelong process, beginning at the preschool level and continuing through all formal and nonformal stages;
3. be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;
4. examine major environmental issues from local, national, regional, and international points of view so that students receive insights into environmental conditions in other geographical areas;
5. focus on current and potential environmental situations while taking into account the historical perspective;
6. promote the value and necessity of local, national, and international cooperation in the prevention and solution of environmental problems;
7. explicitly consider environmental aspects in plans for development and growth;
8. enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
9. relate environmental sensitivity, knowledge, problem-solving skills, and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;
10. help learners discover the symptoms and real causes of environmental problems;
11. emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;
12. utilize diverse learning environments and a broad array of educational approaches to teaching, learning about and from the environment with due stress on practical activities and first-hand experience.

What Can Environmental Education Look Like?

- Tbilisi Declaration (1977) – Objectives of EE
  - Awareness, Knowledge, Attitudes, Skills, Participation/Action
- Purpose – to create "a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution" Journal of Environmental Education
- EE is built on the principles of sustainability, focusing on how people and nature can exist in productive harmony
- As a field it focuses on learners of all ages (early childhood to seniors), on the importance of experiential, interdisciplinary education. It aims to help all learners develop problem-solving and decision-making skills, understand how to be a civically engaged citizen, and how to create a more diverse, inclusive, and equitable society. EE also advances key societal issues—from the Next Generation Science Standards to STEM to climate change education (topic of next workshop!)

Why should we care?

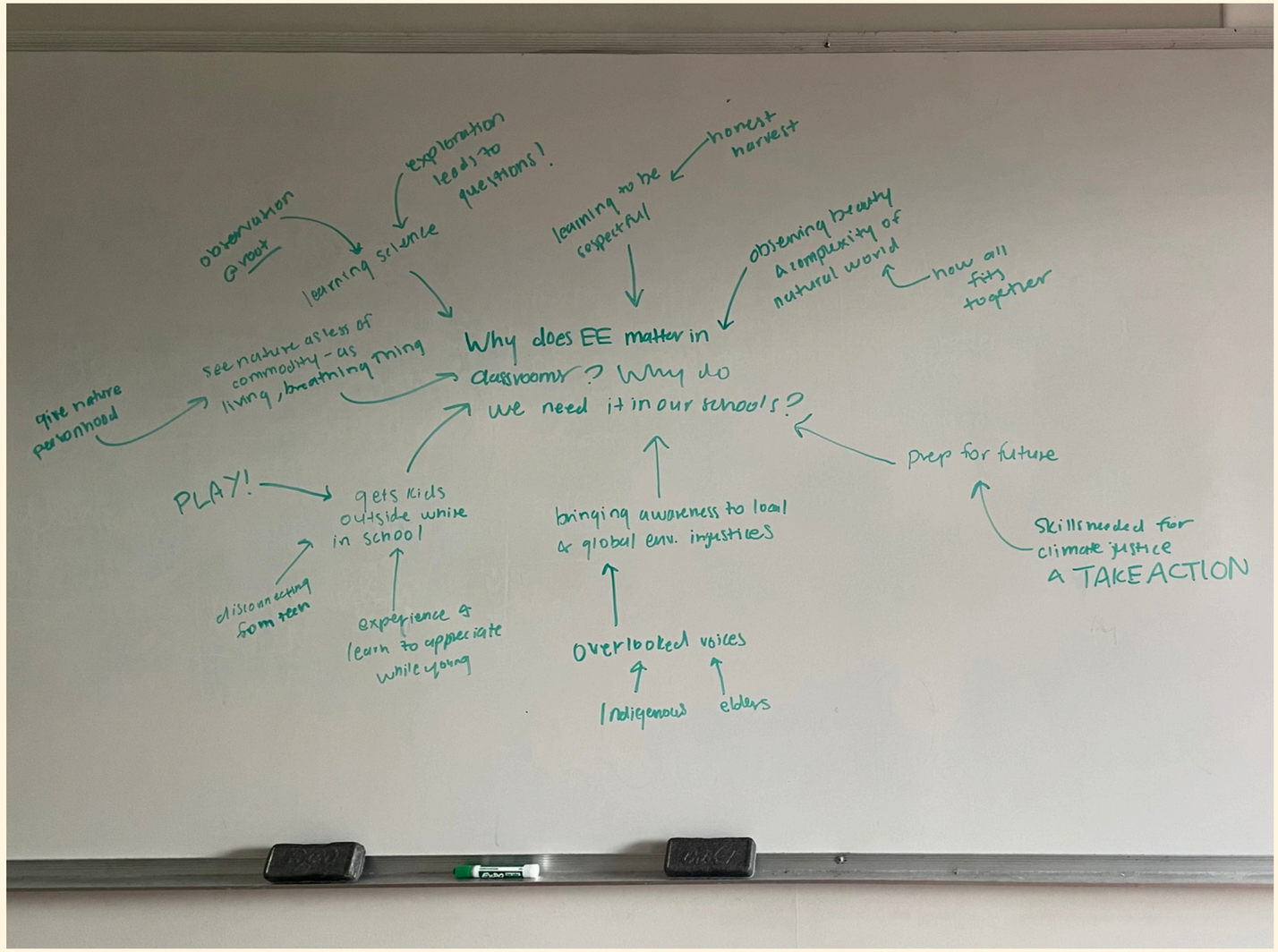
- Environment is important!
  - Sustains all life, nourishment, inspiration, supports economies, physical & psychological benefits, personal & cultural identities
- Environmental, social, and economic challenges
  - Climate change, biodiversity loss, decline in civic engagement, decreasing access to nature, growing gap between have's and have not's, and other threats to health, security & future survival
- "students who participated in environmental education programs improved their academic performance, critical thinking skills and personal development. In addition, these programs fostered life skills such as self-confidence, autonomy and leadership while increasing civic engagement and positive behaviors related to the environment" Forbes

Mind Map

Now that we're all on the same page about what EE is and why it's important, we are going to create a mind map whith all of your ideas for answering this prompt:

Why does environmental education matter in the classroom? Why do we need it in our schools?

Mind Map


observation & wonder
exploration leads to questions!
learning science
learning to be respectful
honest harvest
observing beauty & complexity of natural world
how all fits together
Why does EE matter in classrooms? Why do we need it in our schools?
see nature as less of commodity - as living, breathing thing
give nature personhood
PLAY!
gets kids outside while in school
disconnecting from teen
experience & learn to appreciate while young
bringing awareness to local & global env. injustices
Overlooked voices
Indigenous
elders
prep for future
Skills needed for climate justice & TAKE ACTION

A Teacher's Role

- Modeling nature connection
- Inspiring future leaders
- Required by law!
  - Environmental Education Principles and Concepts
  - Next Generation Science Standards
  - Assembly Bill 285
- "Practicing what you preach"

Sit Spot #2

We are going to do the sit spot activity again, but this time I would like you to imagine yourself as a student of your choice.

I encourage you to really try to get in the mind of your chosen student and think about how this activity would go from their perspective.

Discussion

How did that feel differently this time?

Was it easier for you to sit quieter this time? Was it more difficult? Why or why not?

Is this activity someting you could see yourself doing as a teacher? How would you modify it to fit into your lessons and curriculum?

Activities & Examples

- Nature journaling
- Awe walks
- Field trips – virtual & in-person!
- Scavenger hunt
  - Little Explorers: A Nature Adventure for K-2 Learners
- What other ideas come to mind?

Integrating EE into Classrooms

Language Arts - books, poems, short stories, literary analysis, essays

Math - data collection & graphing, statistics, geometry & measurement, problem solving

Social Studies - global environmental issues, history of environmentalism, civic responsibility & advocacy

Science - ecosystems, biodiversity, climate science, earth science, pollution, conservation, labs

Gratitude
by Mary Oliver

Conclusion

"Being naturalized to place means to live as if this is the land that feeds you, as if these are the streams from which you drink, that build your body and fill your spirit. To become naturalized is to know that your ancestors lie in this ground. Here you will give your gifts and meet your responsibilities. To become naturalized is to live as if your children's future matters, to take care of the land as if our lives and the lives of all our relatives depend on it. Because they do."

— Robin Wall Kimmerer, Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants

Next Workshop: NGSS & Climate Change - Bringing Climate Science into the Classroom

References

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https://www.forbes.com/councils/forbestechcouncil/2024/03/08/virtual-field-trips-bringing-environmental-education-to-k-12-classrooms/

Lesson #1 Reflection:

In teaching this first lesson I feel like I have a good start. I didn't have a lot of students to teach to but that is ok I think because it meant it was a bit more relaxed. Both Olivia and Dani were super enthusiastic and engaged during the lesson and seemed receptive to the material. I asked if they would think about using any of the activities when they are teaching their own classes and they both said "yes!" Olivia mentioned she liked the journaling activity a lot and could really see the potential for benefit and deeper personal reflection that could come from doing this more regularly.

When I asked the participants about what they thought environmental education was, they said that to them it meant learning about climate justice and the environment in general, the effects that are being seen on small and global scales, natural cycles, climate systems, anthropogenically induced climate change, and spreading awareness about environmentalism. They also brought up how it's important to recognize the threats that exist to their local communities and we had a lengthy discussion about students being glued to technology and the use of tech in schools. Dani pointed out that "we have to get them away from their virtual environment and make them see that they have a real environment!" The participants also thought that there needs to be more creativity in the way we teach subjects and that integrating environmental education may achieve this; the power of imagination and forward thinking was also discussed, particularly for teaching and modeling environmental awareness in younger students. Karin, another participant said "only what we imagine can we create."

I found myself asking questions during the lesson that I had not previously come up with and I pivoted a bit based on how I felt like the group was feeling during the workshop. Some things for myself that I would like to do differently are to not worry so much about getting through the whole presentation and to plan more activities rather than lecturing. I also want to be ore of a resource-provider for participants and to make sure to send all of the workshop materials out to them afterwards for their own use

Lesson Plan For 2025 Environmental Education (EE) Unit

Title of Lesson: Bringing climate science into the classroom

Instructors: me (Maddi)

Student/Audience Description: Club members & board from CalTeach Together @ UCSB (undergraduate students w/ interest in STEAM and env ed and in becoming teachers)

Amount of Time for the Lesson: Length of club meeting (usually ~45 min to an hour) *but in combination with lesson 3

Management Considerations: Not set number of people, not all members come to every meeting

Materials: Presentation slides, journal packets

Cognitive Objectives: Participants will understand the structure and relevance of NGSS climate-related standards and how they apply to different grade levels and be able to interpret key components of new climate education legislation.

Affective Objectives: Participants will be able to recognize the importance of climate literacy as part of responsible, future-focused teaching and will develop a sense of responsibility to prepare students for climate-related challenges in their communities and lives.

due to conflicts in coordinating scheduling with CalTeach club at end of quarter, decided to teach combined lesson 2 and 3 to just other CalTeach president Olivia (who was very gracious to be my student for these lessons :)

Step-by-Step Procedures - 5E's *using instead of Natural Learning Cycle

Engage:

To begin the lesson, all participants will sit in a circle and we will go around and share our names and what we are feeling grateful for today. Next, the instructor will share a brief overview and roadmap of what the lesson and activities are going to look like; this all should take about 2 minutes.

Next, we will do a short recap of the first workshop to refresh participants' memories and get those who were not present at the first workshop up to speed (if applicable). Again this should take no more than 2 minutes.

The objective of this section is to spark interest and connect participants' prior knowledge to climate change education. We will do a 5 minute journaling session based on the prompt "Why should students learn about climate change?" After participants have time to gather their thoughts we will come back together as a group and discuss. Following this, the instructor will introduce the importance of climate literacy in shaping informed, resilient communities and provide some initial resources.

To transition to the next section we will continue our conversation about why teaching climate change matters to educators and their students and reiterate how we will explore how to make climate science a part of participants' future classrooms

Explore:

Now, participants will be allotted time to investigate teaching standards and laws related to climate education. The instructor will give a short overview of what Next Generation Science Standards (NGSS) are and give a short timeline of the legal process of getting climate change education into California curriculum. Participants will either individually or in pairs (depending on how many participants there are) read NGSS standards that relate to climate (ESS3: Earth & Human Activity (C & D specifically) and LS2: Ecosystems, Interactions, Energy and Dynamics (C specifically)) and will read a short summary of the Climate Change Education Act and Assembly Bill 285: Climate Change Instruction.

Next, participants will identify what the standards/laws say, where this fits into their grade band of choice (to be chosen and communicated to the instructor at the start of the activity), and what opportunities or challenges they foresee in how this legislation will play out in real time in the classroom. They will also be asked to consider questions like "What does your grade band emphasize in climate science?", "What are the expectations under the new law or policy?", and "How might this change classroom conversations or curriculum?" Participants will be given 15 minutes to do this and will share out to the whole group their main takeaways.

Explain:

The instructor will then go into more detail and explanation to ensure that participants are building a clear understanding of NGSS and legislation through direct instruction and discussion. A mini lecture (roughly 10-15 minutes in duration) will go over the structure of NGSS, reviewing Disciplinary Core Ideas (DCIs), Science & Engineering Practices, and Crosscutting Concepts, where climate change fits into every standard by grade band, and reiterate relevant state and federal mandates for climate change education. The instructor will pull from resources such as Seeds to Solutions, 10 Strands, C-Justice, and Climate Generation.

Elaborate:

To apply understanding to a teaching context and build on the educator's emotional investment, participants will brainstorm methods of how best to approach a sensitive and difficult topic like climate change in the classroom. As a group we will digest and discuss questions like:

How should educators' support students mental health while they learn about climate change?

What emotions, thoughts, and feelings do you anticipate would arise in your students from talking about climate change?

How could teaching about climate change be combined with nature connection and environmental education in schools?

This will be about 5 to 10 minutes depending on the direction of the conversation

Evaluate:

To evaluate participants learning they will be asked to write answers to an exit ticket in their journals based on the following prompts:

"One new thing I understand about NGSS and climate education laws is…"

"One way I can help my students become more climate literate is…"

"I now feel ___ (1–5) prepared to incorporate climate education into my teaching."

The workshop will end with a wrap up discussion where the instructor will reinforce key messages that climate literacy is both a professional responsibility and an opportunity to empower students and will share a list of resources for participants benefit and future use

Assessment (that matches with the original Objectives)

The instructor will perform formative assessments during the lesson to evaluate participants progress by listening and documenting key understandings and misconceptions that participants share during group discussions. The exit ticket will serve as the summative assessment and will ensure participants have gotten at least one thing out of each section of the workshop

Explanation of How You Have Address ALL 4 Learners—Use 4MAT Theory to Explain

Type 1: Insight

This lesson addresses this learning style through personal gratitude sharing which helps build community and trust, journaling on “Why should students learn about climate change?” allows for emotional and value-based connection, and group discussion and instructor framing connect the topic to participants' lives and values.

Type 2: Analytic

Analytic learners will appreciate reading and interpreting NGSS standards and laws, the instructor mini-lecture that provides clear, factual explanations of NGSS structure, legal mandates, and frameworks, and the addressing of key concepts such as Disciplinary Core Ideas and state laws.

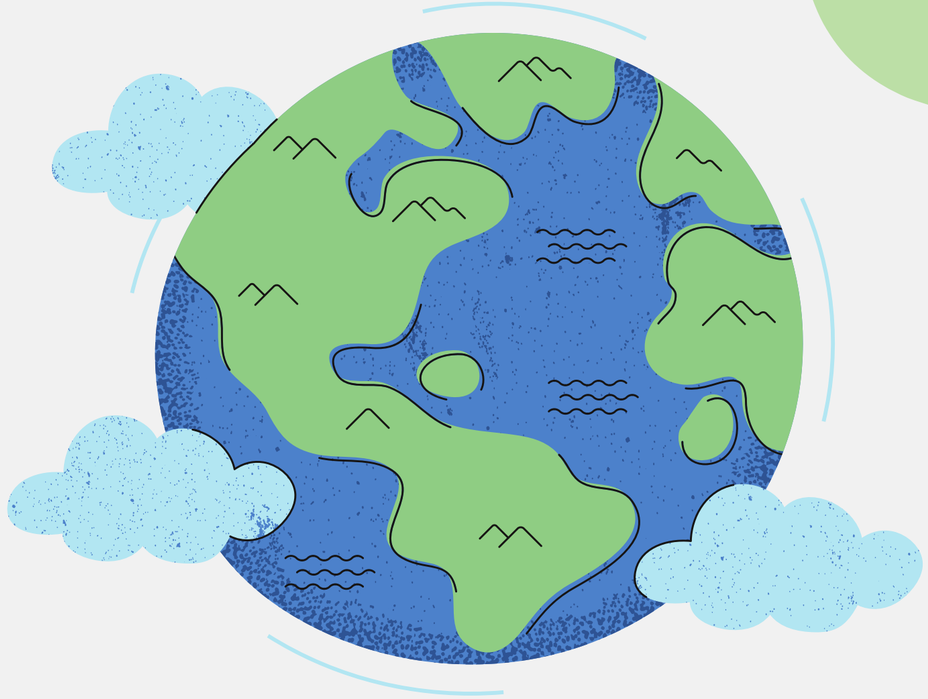
Type 3: Common Sense

This lesson addresses this learning style as participants identify how standards and laws apply to their grade levels, are asked to brainstorm classroom challenges and adaptations allowing for practical application, and are given real-world context (CA laws, standards, classroom discussion prompts) that reinforces relevance and use.

Type 4: Dynamic

Dynamic learners will appreciate the open-ended, future-focused questions asked, how participants are encouraged to be innovative and explore teaching approaches as well as the exit ticket reflection which fosters self-direction and identifies next steps for real-world application.

Bringing Climate Science into the Classroom



Env S 127B - Advanced EE & Practicum
Workshop #2
Maddi Conrad

CalTeach Together @ UCSB

Roadmap

1. Intros & gratitude circle
2. Recap from Workshop 1
3. Journaling & discussion
4. Climate literacy
5. NGSS & climate laws
6. Classroom connections
7. Final reflection
8. Conclusion & resource library

Workshop #1 Recap

- Understanding Nature Connection
  - Experiences in nature can inform our teaching
- What is Environmental Education?
  - Discipline & practice
  - NAEE & UNESCO definitions
  - Tbilisi Declaration's 12 guiding principles
- Practical EE Application
  - What is our role as teachers/educators?
  - Why is important for students to receive an environmental education?

Journaling

Why should students learn about climate change?

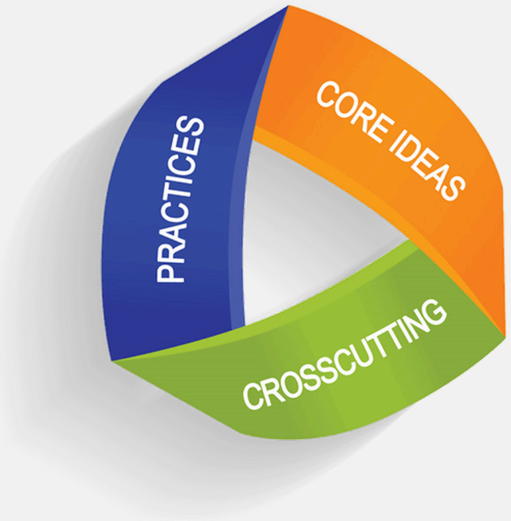
Climate & Environmental Literacy

Being environmentally literate means to understand the essential principles of Earth's climate system, how it works, how human actions influence it, and the impacts of climate change . Teaching younger generations about climate change and environmental processes aids in shaping informed and resilient communities; for their future well being, it is crucial for students to become literate in climate issues as it prepares them for the future, builds personal resilience and agency, and supports civic engagement

“Every student in California can achieve environmental literacy, and all students deserve the opportunity to understand, interact, and connect with their environment in meaningful ways that promote learning and growth. Ten Strands acts as a connector, building partnerships and forging pathways to ensure that California’s TK–12 students receive a high-quality education with an environmental component. Together, we can create a healthy future for our planet and its inhabitants.” Ten Strands

What are Next Generation Science Standards?

"The Next Generation Science Standards (NGSS) are K–12 science content standards. Standards set the expectations for what students should know and be able to do. The NGSS were developed by states to improve science education for all students" NGSS



1. **Cross Cutting Concepts** - help students explore connections across the four domains of science. When concepts, such as "cause and effect", are made explicit for students, they can help develop a coherent and scientifically-based worldview
2. **Science & Engineering Practices** -describe what scientists do to investigate the natural world and what engineers do to design and build systems. They explain and extend what is meant by "inquiry" in science and the range of cognitive, social, and physical practices that it requires. Students engage in practices to build, deepen, and apply their knowledge of core ideas and crosscutting concepts.
3. **Disciplinary Core Ideas** - key ideas in science that have broad importance within or across multiple science or engineering disciplines. They build on each other as students progress through grade levels and are grouped into the following four domains: Physical Science, Life Science, Earth and Space Science, and Engineering.

State & Federal Climate Education

S.4117 Climate Change Education Act

- Initially created by Senator Barack Obama and Representative Michael Honda in 2007
- Re-introduced in 2009, 2016, 2018, and 2024
- Creates an Office of Climate Change Education at NOAA
- Authorizes up to $40 million for that office to make grants to state educational agencies, colleges and universities, professional associations and academic disciplinary societies, and youth corps organizations
    - Professional development, teacher training, climate change curriculum development, application of climate reserach

Assembly Bill 285: Climate Change Instruction

- Signed into law in 2023
- Requires K-12 climate education in California
- Supported by both the California Next Generation Science Standards (CA NGSS), and the 2016 Science Framework for California Public Schools: Kindergarten Through Grade Twelve (Science Framework which address climate change education in extended detail

Practice with NGSS

- Read standards + laws
- Pick grade band
- Identify what the standards/laws say, where this fits into grade band of choice, what opportunities or challenges they foresee in how this legislation will play out in real time in the classroom
- Questions to guide exploration:
  - What's emphasized?
  - What does the law say? What are the expectations?
  - What would this look like in class and how might this change conversations or curriculum?
- We will come back together and share our main takeaways as a group!

1. An inquiry-based approach where students (and teachers) are provided opportunities to make observations and ask questions that lead to deeper understanding and action.
2. An integration of the core content and skills outlined in the Common Core State Standards (CCSS), Next Generation Science Standards (NGSS), California's Environmental Principles and Concepts (EP&Cs), and other relevant standards and frameworks.
3. The use of equity-focused frameworks such as, but not limited to, Culturally Relevant and Responsive Pedagogy, Universal Design for Learning, Indigenous Ways of Knowing, and honoring the knowledge and experiences students already possess.
4. An interdisciplinary approach where themes, concepts, skills, and content knowledge across multiple disciplines are required to meet the project's challenges and provide students with authentic approaches to problem-solving in the 21st century.
5. A data literacy approach where teachers and students identify potential local issues and look for patterns in local data sets, and develop and use models and other explanations that illuminate these issues.
6. A focus on helping students acquire and develop the skills of data science, analysis, and interpretation; expression, including writing, presentations, and multimedia; inquiry; and civic engagement.
7. An explicit focus on how environmental issues disproportionately benefit or harm some populations more than others and create injustices that ultimately impact everyone.

Ten Strands
Connecting Education, Environment, and Community

DEPARTMENT OF EDUCATION STATE OF CALIFORNIA

SAN MATEO COUNTY OFFICE OF EDUCATION

Seeds to Solutions

" Seeds to Solutions™ empowers students in grades K–12 to be environmentally literate, engaged community members through free, solutions-oriented instructional materials on California-specific environmental issues."

Seeds to Solutions: Units by Grade Level

- **Elementary**
  - **Kindergarten** - Observing Our Natural World
  - **1st Grade** - Food Waste
  - **2nd Grade** - Open Space
  - **3rd Grade** - Extreme Tempeartures
  - **4th Grade** - Power Outages & Energy Systems
  - **5th Grade** - Wildfires
- **Secondary**
  - **6th Grade** - Food Systems *sometimes elementary
  - **7th Grade** - Land Subsistence & Groundwater
  - **8th Grade** - Air Quality
  - **9th & 10th Grade: Life & Env. Science** - Managing Water for CA Communities & Ecosystems
  - **9th & 10th Grade: Physical & Env. Science** - Greenhouse Gas Emissions & Consumerism
  - **11th & 12th Grade: Interdisciplinary Env. Science** - Engaging in Research & Conducting Case Studies

C-Justice

Climate Justice in Undergradute STEM
Incorporating Civic Engagement

Discipline Specific Idea Tables

C-JUSTICE

Climate Justice in Undergraduate STEM Incorporating Civic Engagement

NSF DUE 2043535

Discipline-Specific C-JUSTICE Idea Tables

Chemistry Biology Computer Science Math/Statistics Physics Meteorology/Geology/Oceanography

This document contains ideas and examples of how you can teach your STEM content "through" climate justice and community and civic engagement. Tables below, for STEM disciplines include: Chemistry, Biology, Computer Science, Geology/Oceanography, Math/Statistics, Physics, Computer Science, Meteorology, and more. Each STEM discipline table has five columns with the following information:

Climate Justice Community or Social Justice Connection	Climate Science Connection	Textbook Chapter or Course Content	Course Concept (To Know) and or Skill (To Do)	Civic or Community Engagement Activity	Positive Story of Change for Climate Justice
Describes climate justice issues facing the world today and in the future. In the Chemistry example table below, each issue is selected to show how disciplinary content and/or skills can be taught in connection to the issue and does not contain a comprehensive list of all climate justice issues. SENCER helps us teach "through" climate justice by introducing a compelling and complex climate justice issue first, as a way to engage students, and then delving into the STEM content and/or skills needed to understand and address the issue through civic or community engagement.	Connects the climate justice issue to the climate science behind the issue. This will help connect the climate justice issue closer to the STEM content and/or skills that you need to teach in a given course.	List of disciplinary content and/or skills as it is typically grouped and sequenced in textbooks and/or throughout a specific STEM course.	Lists specific STEM disciplinary concepts and/or skills contained in certain chapter material that can be taught "through" a given climate justice issue.	Students disseminate their knowledge & solutions to the community and/or engage with or participate in the world in a civic/democratic way. STEM students, instructors, and practitioners are encouraged to have and share their educated opinion about things that they've researched and understand.	Share or brainstorm a positive story of change that you could share with your students that is related to the climate justice issue that is the focus of your module

This is a living document which is very much in-progress. Please help us make connections between climate justice and the disciplinary content that you teach in your STEM courses. Send your suggestions to heather.price@seattlecolleges.edu or sonya.doucette@bellevuecollege.edu

Overcoming Disinformation

Build the capacity to deepen and scale our efforts to overcome disinformation through engaging educators, students, and communities where it is most prevalent.

Centering anti-racism and systemic equity

By working with BIPOC partners to center marginalized communities and diverse perspectives, we will build shared understanding about the intersectionality and convergence of racial and climate justice.

Personalizing and localizing climate change action

Work with communities to personalize and localize actions undertaken in addressing the climate crisis through employing strategies of personal story, awareness, education, and advocacy.

"Climate Generation ignites and sustains the ability of educators, youth, and communities to act on systems perpetuating the climate crisis."

- Teach Climate Network
- Regional Education Support
- Youth Activism
- UN Climate Conferences
- Resource Library
  - Lesson plans & curriculum
  - Stories & guides
  - Activities
  - Toolkits
  - Videos

Climate Generation

Classroom Connections

How should educators' support students mental health while they learn about climate change?

What emotions, thoughts, and feelings do you anticipate would arise in your students from talking about climate change?

How could teaching about climate change be combined with nature connection and environmental education in schools?

Exit Ticket

“One new thing I understand about NGSS and climate education laws is…”

“One way I can help my students become more climate literate is…”

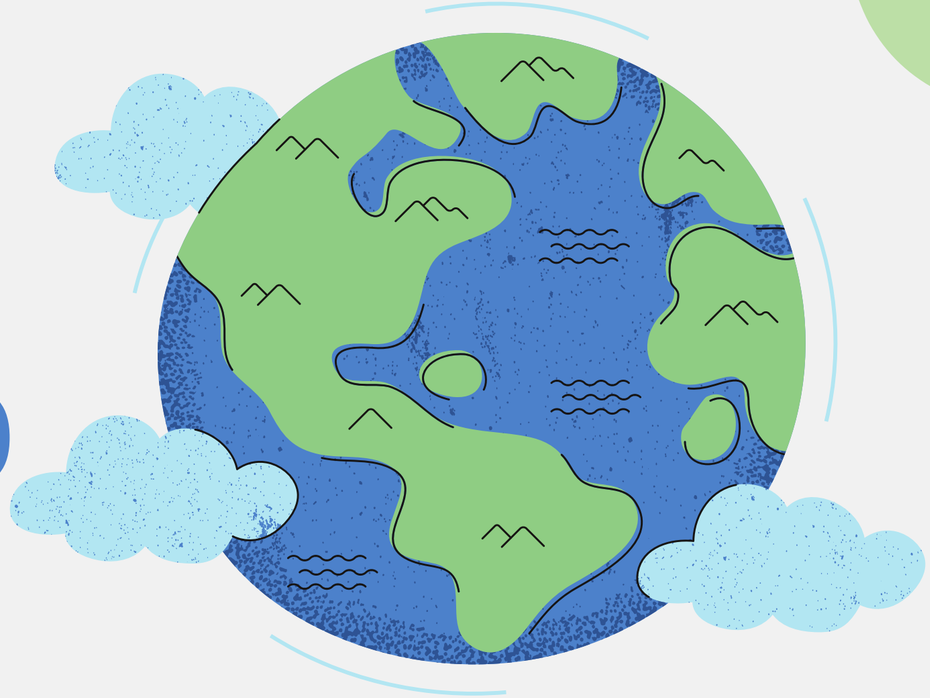
“I now feel ___ (1–5) prepared to incorporate climate education into my teaching.”

Resource Library

- Next Generation Science Standards (NGSS)
- NGSS for California Public Schools, K-12
- Campaign for Climate Literacy
- Ten Strands
- Subject to. Climate - lesson plans, guides, activities, teaching tools
- Climate Generation - resource library
- STEM Teaching Tools - blog posts, resources, external links

Thank you!

Next...workshop #3!!



Lesson #2 Reflection:

I feel better after teaching this lesson as it was kind of a scramble to get it taught. I ended up teaching it only to the other CalTeach president as I was having a lot of issues with trying to get a meeting scheduled with the whole club; we also don't tend to have meetings later in the quarter as everyone gets busy with schoolwork and preparing for finals. I also decided to teach this lesson in combination with lesson 3 (teaching them one after the other). Despite these challenges, I feel like Olivia got a lot out of the lesson and she was very gracious to be a solo participant.

What went particularly well I would say was having journaling and discussion questions mixed in with independent work. It was cool to take the time to talk with Olivia and have me almost act like a participant as well and then have her do her own research and review of the NGSS standards. This lesson I feel also went well for Olivia as she does not have much experience talking about climate change and it seemed like she learned a lot about climate science itself but also how to teach it to others and integrate it into her future classroom. What I would do differently is to have this lesson with more people as I feel like I designed it with more people in mind and structured it to have people work in pairs or small groups.

I would say yes, my participant attained the objectives laid out for the lesson. She expanded upon her working knowledge of NGSS standards by seeing how they can be applied to climate change education specifically. In her exit ticket, Olivia talked about how she has a greater understanding of how NGSS and climate laws are crucial aspects of a science education and that she could help her students become more climate literate by incorporating climate science in small bits over many different lessons. She had also not heard of Assembly Bill 285 before these workshops (I mentioned it in workshop 1 and expanded upon it in this one), and mentioned that she was excited to think of the lessons she will teach about climate change to her future students.

Olivia was engaged during the entire lesson and our discussions served as a way for me to gauge her understanding and grasp on the content. The exit ticket I think also worked well to see how she was feeling after the entire lesson and what was working for her. Based on this lesson I want to make sure that I gauge how participants feel after each lesson by doing an exit ticket-type ending activity.

Lesson Plan For 2025 Environmental Education (EE) Unit

Title of Lesson: Integrating Environmental Education & Climate Science Into a Science Lesson

Instructors: me (Maddi)

Student/Audience Description: Club members & board from CalTeach Together @ UCSB (undergraduate students w/ interest in STEAM and env ed and in becoming teachers)

Amount of Time for the Lesson: Length of club meeting (usually ~45 min to an hour) *but in combination with lesson 2

Management Considerations: Not set number of people, not all members come to every meeting

Materials: Presentation slides, journal packets

Cognitive Objectives: Participants will be able to identify local climate issues and apply them to the development of place-based and standard-aligned lesson plans. They will also be able to design a classroom activity and/or mini lesson that integrates climate science with appropriate instructional methods and local relevance.

Affective Objectives: Participants will feel more confident and motivated to teach climate change, regardless of previous experience or content knowledge and appreciate the value of age-appropriate instruction that empowers, rather than overwhelms students. Participants will also foster a connection to local environmental issues, seeing them as valuable entry points for student engagement and civic action.

Step-by-Step Procedures - 5E's *using instead of Natural Learning Cycle

Engage:

As this is a continuation of lesson 2 we will not begin with intros, gratitude or a refresher of the previous lesson. To spark curiosity and build personal connections for this part of the workshop we will start with a 5-10 minute discussion around the prompt "What local environmental change have you noticed in your hometown or in the UCSB/IV community?" The instructor will also include pictures of local climate impacts to Santa Barbara county such as drought, wildlife, coastal erosion, etc. to help participants connect. We will also discuss the question "Why do you think it's important to teach climate change in K–12 settings? What's hard about it?"

As a transition the instructor will talk about the connecting idea between all of these workshops which is about integrating local climate issues into NGSS-aligned and age-appropriate science instruction to empower (not overwhelm) our students.

Explore:

Participants will be given a chance to examine the Climate Justice Framework and in pairs or individually they will do some independent research on local Santa Barbara climate and environmental issues (supplemented from our previous discussion). Then they will select one or two elements of the Climate Justice Framework that relate most closely to their chosen climate

issue. Participants will then be asked to identify an NGSS disciplinary core idea that aligns with their issue of choice. This should take roughly 10 minutes.

Afterwards we will rejoin as a group and discuss what grade level participants might want to teach and how these issues and concepts could be introduced at that level by using the prompt "How does the Climate Justice Framework help you think about teaching this issue with respect to both science content and environmental literacy?"

Explain:

Next, the instructor will give an overview of what exactly climate justice is in order to provide participants with more working knowledge of how best to teach in a way that engages students with climate science and prepares them for the impacts of climate change

Elaborate:

Now using what they have come up with for a local issue, connecting Climate Justice Education Framework element, connecting NGSS DCI, and thinking about grade level considerations, participants will be asked to apply their understanding by designing a mini lesson or activity at their chosen grade level. In their journal packets, participants will sketch out a brief lesson plan or classroom activity that incorporates science content from their NGSS DCI, climate justice concepts, student engagement strategies that empower and connect students to local issues, and age-appropriate instructional methods. Participants will be given at most 15 minutes to do so and the instructor will circle through groups/individuals and will ask the workshop group as a whole prompting questions such as "How will you help students see the local impact?", "What inquiry or hands-on activities can you include?" and "How will you integrate justice and equity perspectives?"

The instructor will also provide more resources to lesson plans and units of instruction from Ten Strands and the Coastal Commissions California Environmental Education Interagency Network.

Evaluate:

The very final portion of the workshop will be focused on particpatnt's reflection on the process of designing their lessons. First, each will briefly share their lesson (almost as an elevator pitch) and their peers will be encouraged to offer constructive feedback and ideas. As a final journal reflection prompt, participants will be asked to write a response for the following prompts:

What is one aspect of your lesson you feel excited to implement?

What challenges do you anticipate in teaching climate justice topics?

How has your confidence or perspective on teaching climate science evolved through these workshops?

Assessment (that matches with the original Objectives)

Participants will be assessed based on their engagement throughout the workshop and their design of a mini lesson/activity. A final reflection in their journal packets will serve as their exit ticket and will demonstrate their learning that they have gained and feelings that have arisen from their participation in this workshop and the unit as a whole.

Explanation of How You Have Address ALL 4 Learners—Use 4MAT Theory to Explain

Type 1: Insight

This workshop addresses the insight learning style because it begins by tapping into participants' personal experiences with local environmental changes in their communities. The reflection prompts participants to explore their feelings about the teaching process, including challenges and confidence gained, further supporting these learners' need for meaning and personal relevance.

Type 2: Analytic

Analytic learners will appreciate researching and analyzing local Santa Barbara climate issues, using the Climate Justice Framework and NGSS disciplinary core ideas, which provide a structured, conceptual foundation. The instructor's overview of climate justice also offers clear definitions and frameworks to build their knowledge base.

Type 3: Common Sense

This workshop addresses the common sense learning style by applying what participants have learned by designing a mini lesson or classroom activity; this hands-on planning in journal packets emphasizes practical "how-to" strategies that these learners will appreciate. Having additional resources also offers concrete tools and examples to support the implementation of their learning to design a lesson.

Type 4: Dynamic

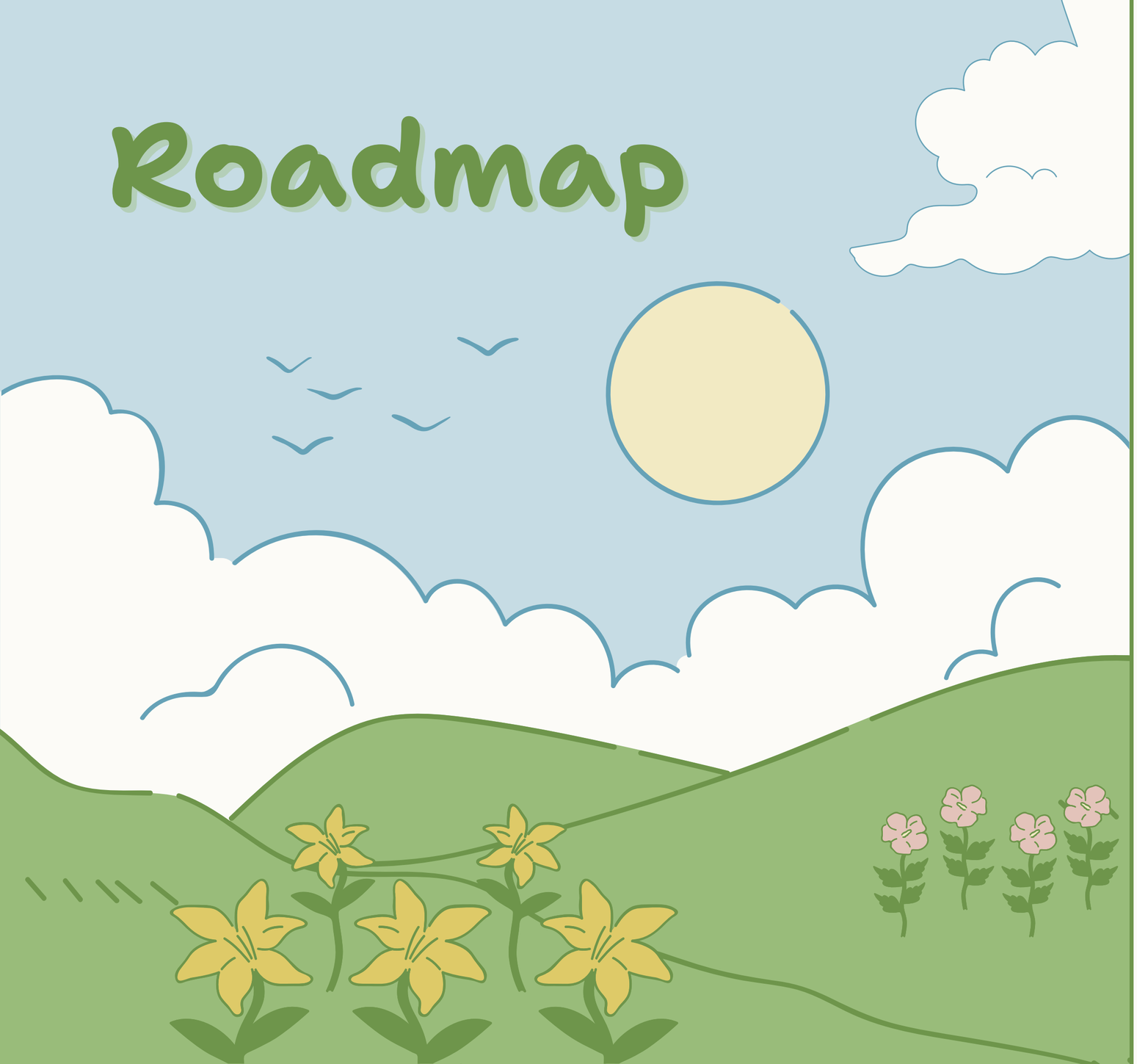
Dynamic learners will appreciate being encouraged to think creatively about integrating climate justice and NGSS content and imagining new ways to engage and empower students with local issues.

Integrating Environmental Education & Climate Science Into a Science Lesson

Env S 127B - Advanced EE & Practicum
Workshop #3
Maddi Conrad

CalTeach Together @ UCSB

Roadmap

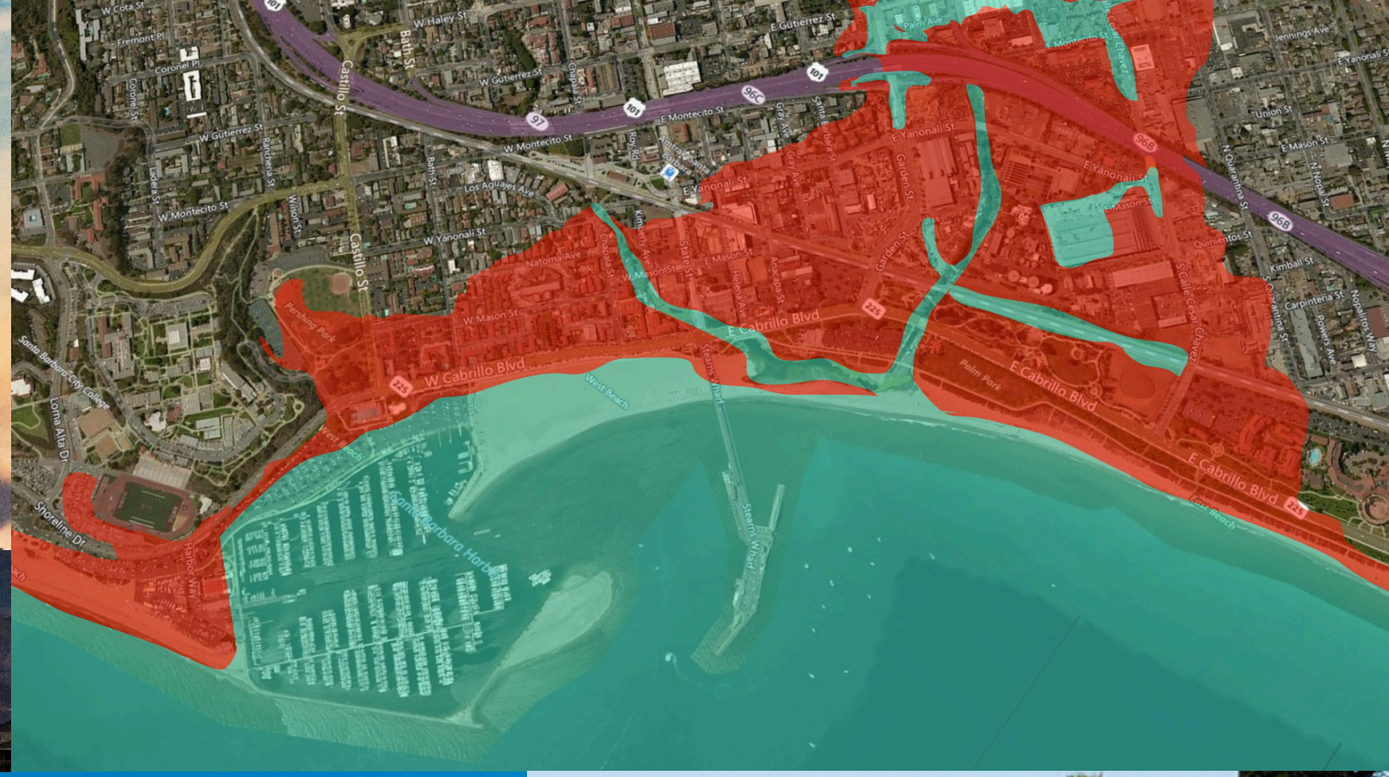


1. Discussion
2. Connecting Idea
3. Climate Justice Education Framework
4. What is Climate Justice?
5. Designing Mini Lesson
6. Additional Resources
7. Final Reflection

Discussion

What local environmental change have you noticed in your hometown or in the UCSB/IV community?

Why do you think it's important to teach climate change in K–12 settings? What's hard about it?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Stearns Wharf
West Beach
East Beach
Palm Park
Los Aguajes Ave
Natoma Ave
Santa Barbara City College
Lone Alta Dr
Shoreline Dr
Garden St
Quinientos St
Cliff Drive
Carpinteria St
Kimball St
Nopalito Way
Bowers Ave
Henning Ave
Union St
N Milpas St
N Quinientos St
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Nectarina St
Wilson St
Kellogg Ave
Olive St
Chapala St
Anacapa St
Santa Barbara St
Milpas St
Ortega St
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Connecting Idea

Integrating local climate issues into NGSS-aligned and age-appropriate science instruction to empower (not overwhelm) our students.

Climate Justice Education Framework

1. Research a climate/environmental issue in SB County
2. Select 1-2 elements of the Climate Justice Education Framework that relate to your chosen issue
3. Identify NGSS Disciplinary Core Idea that relates to your issue and chosen elements
4. Start thinking about how can these issues and concepts be introduced to a specific grade level

How does the Climate Justice Framework help you think about teaching this issue with respect to both science content and environmental literacy?

What is Climate Justice?

"Teaching STEM Through Climate Justice and Civic Engagement" Teaching & Learning

Climate Change & Social Justice

First, climate justice sits at the intersection of climate change and social justice. This means that climate change and climate science are not value-neutral but instead are connected to social issues in the world

Issue of Equity

Second, the mobilization of resources for climate mitigation and adaptation is an equity issue when it comes to who gets what resources

Collective Action

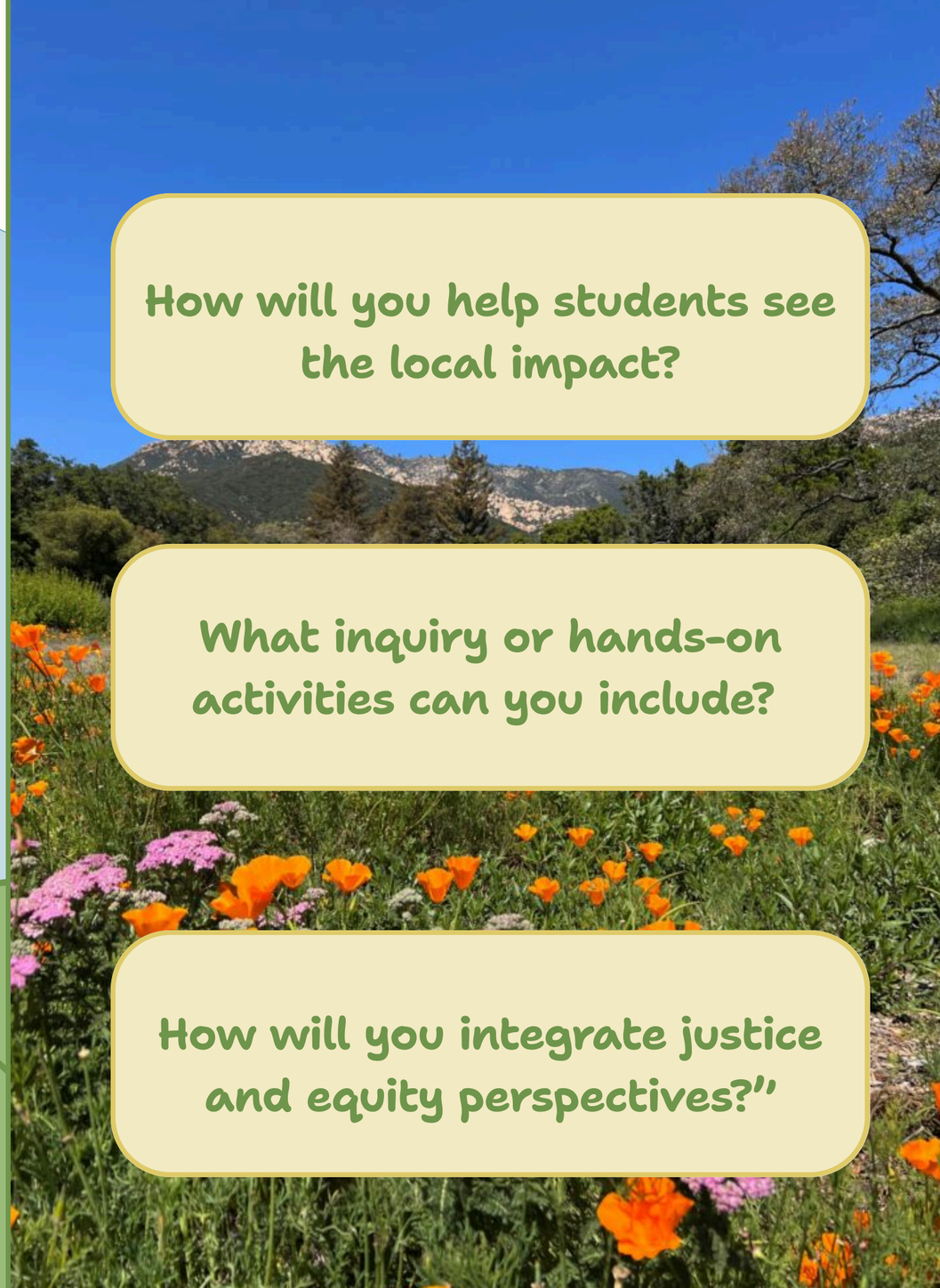
Third, climate justice is about networks for collective action, not only individual behavior change. Grassroots organizations, and community organizations and efforts, are at the heart of climate justice because they offer a collective voice that is more powerful than any individual voice and this collective voice is grounded in the real life opportunities and struggles of people in communities most impacted by climate and environmental injustices.

Participation

Finally, climate justice involves equitable participation in decision making, policy development, and implementation, including in the field of education.

Create a mini lesson/activity!

Now, you will apply what you have explored to design a mini lesson or classroom activity about your chosen climate change impact at your chosen grade level. Be sure to include science content from your chosen NGSS DCI, climate justice concepts, student engagement strategies that empower and connect students to local issues, and age-appropriate instructional methods



How will you help students see the local impact?

What inquiry or hands-on activities can you include?

How will you integrate justice and equity perspectives?"

Additional Resources

California Coastal Commission California Environmental Education Interagency Network

Comprehensive list of CEEIN members and partners such as California Department of Education, California Environmental Protection Agency, The Resources Agency of California, UC Agriculture and Natural Resources, and the California Department of Food and Agriculture that provides links to educational materials and lesson plans

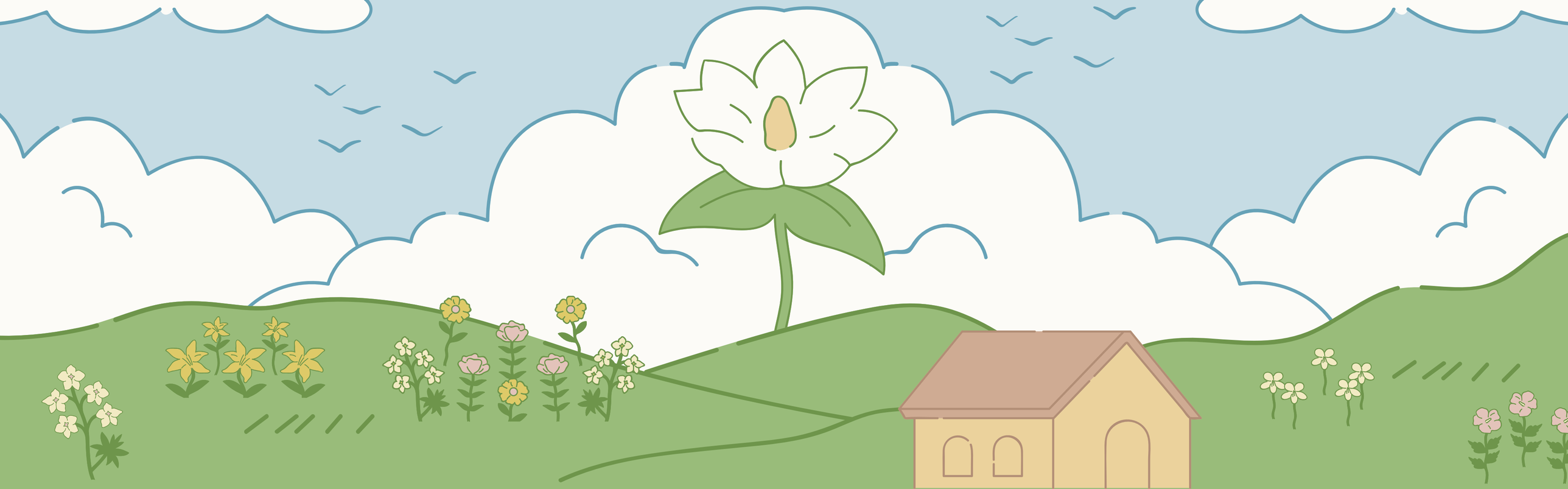
Ten Strands Education and the Environment Initiative Curriculum

Lesson plans approved by the CA Board of Education that aids teachers teach to state standards in science and history–social science using the environment as context. Select units and unit materials are featured in Spanish. Ten Strand's partnered with California's Office of Education and the Environment at CalRecycle to increase access to the curriculum.

Final Reflection

What is one aspect of your lesson you feel excited to implement?
What challenges do you anticipate in teaching climate justice topics?
How has your confidence or perspective on teaching climate science evolved through these workshops?

Thank you all for your participation! Please look out for an evaluation form!



Lesson #3 Reflection:

This lesson was taught directly after Lesson 2 and came with the same challenges of having only one participant. I felt much better after getting both this lesson and the one before, taught to Olivia. I also feel glad that the activity of creating a mini lesson worked well and that Olivia was able to really use the material I had provided her to create a fun lesson for

For this lesson what went particularly well was connecting a local issue to a climate science focused lesson using NGSS standards. I think it was really helpful for Olivia to use something she is familiar with and has experience with, cliff erosion in IV, to connect climate change issues and educational standards into an age appropriate lesson. One thing I ended up doing also was making online worksheets for Olivia to fill out on her iPad as opposed to creating new paper journals. I used the text and content from the slide decks I made on the worksheets so that it was easier for Olivia to see what I was asking of her to write in each section.

This lesson would also benefit from having multiple participants in order to pair people up to create a lesson and allow for group sharing and feedback about each lesson that participants create. Something with this lesson that could be done differently also is having it be place-based; this means that it could be taught in a specific local location where the effects of climate change are actively happening (such as along the bluffs in IV for example) as this would help participants connect how issues in real life can be transformed into lessons in the classroom.

Olivia was able to meet the objectives laid out for this lesson; she created an engaging lesson based on a local issue she identified that utilized the Climate Justice Education Framework, NGSS standards, and grade-appropriate instruction and activities. In our discussion and in her writing she mentioned that having gone through the process of this workshop she feels more prepared to be able to talk about climate change with younger students and be able to recognize the emotional aspect of teaching a difficult subject to students. She also talked about how she had a new understanding for how teaching about climate change can better prepare students to be civically engaged in the future.

Olivia's final reflection served as the main form of assessment aside from engaging in conversation and designing a mini lesson. I would say yes that this reflection did a good job of letting me see her thought process about creating her own lesson plan and how she felt post-participation in the workshop.

Lesson Plan For 2025 Environmental Education (EE) Unit

Title of Lesson: Combining Outdoor & Place-Based Learning at the UCSB Greenhouse Garden Project with Next Generation Science Standards

Instructors: me (Maddi)

Student/Audience Description: Peers in Env S 127B course (Lakshmi, Sami, Anna, Mari, Kelsey, Liv, Natalie, Nallely, Ruby, Morgan, Yahaira) and Bridget (instructor)

Amount of Time for the Lesson: Roughly one hour

Management Considerations: Not everyone comes to every class meeting

Materials: NGSS handouts, exit tickets, lesson handout

Cognitive Objectives: Participants will be able to identify NGSS science standards that are relevant to climate change and environmental literacy and be able to design an age-appropriate garden-based lesson that integrates climate change concepts and NGSS-aligned instruction.

Affective Objectives: Participants will feel more confident in their knowledge of NGSS standards and in using gardens as a site for interdisciplinary, hands-on science learning. Participants will also recognize the power of garden-based learning to foster student agency in understanding and responding to climate change.

Step-by-Step Procedures - 5E's *using instead of Natural Learning Cycle

Engage:

*Before the garden walk we will do acheck-in question to assess everyone's knowledge and experience learning about climate change. The questions asked will be "What do you know about climate change?" and "What does it mean to you?" Participants will be given time to think to themselves and share their ideas to the group

To start, participants will be asked to take 5 minutes to walk about the garden and make observations about potential environmental changes or stressors that they notice in the garden and what effects climate change may have on the future of our garden. After these five minutes we will come back together and share what we observed.

Possible answers could include - warming temperatures, altered growing seasons, increased pests and diseases, changes in precipitation and water availability, drought, altering soil structures and nutrient availability, greater risk of wildfires

We will also have a five-ish minute think-pair-share discussion on the prompts "What role do school gardens play in environmental literacy and science education?" and "How might gardens help us teach students about climate change in a way that feels hopeful and hands-on?"

Explore:

Participants will be asked to spend 5 minutes looking at the NGSS and CA NGSS website and spend time exploring the different links and resources available. Afterwards we will share what we have found (what thought was interesting, what was confusing, what did you already know, what do you want to know more about etc.)

https://www.nextgenscience.org/

https://www.cde.ca.gov/ci/pl/ngssstandards.asp

Explain:

Next, the instructor will give a mini lesson about the three dimensions of NGSS (Disciplinary Core Ideas, Science & Engineering Practices, and Crosscutting Concepts) and will highlight how climate change fits within NGSS by addressing Assembly Bill 285

NGSS overview - written in 2013, rich in content and practice, create science literate citizens, creating common standards for teaching science in U.S., making science and engineering relevant and accessible, deepen students' interest in STEM fields, help students understand core scientific standards, proficiency in scientific process, ability to evaluate evidence

Assembly Bill 285 - signed in 2023 for CA, requires climate change education in K-12, builds upon NGSS standards, climate change affects all of us, taught across different disciplines

We will also have a think-pair-share with the prompt "Why do place-based approaches like gardens matter in climate justice and environmental education?"

Possible answers could include - connecting knowledge to real-world concepts, fostering sense of place, promoting local action, hands-on learning opportunities, raise awareness, food security, reduced carbon footprint

Elaborate:

Next we will pair up and read over the NGSS Disciplinary Core Ideas. Each group will take about 5 minutes to identify a specific garden feature or phenomenon that can be used to teach an NGSS-aligned science concept. Participants will also be asked to identify what grade band this may align with. Each group will spend the next 10 minutes drafting a garden-based mini-lesson plan or activity using a provided handout. The instructor will pose certain questions to the group such as "How will you scaffold science learning while also fostering student climate action or awareness?" and "What questions would you pose to help students connect observation to broader systems or justice issues?"

Evaluate:

At the end of the work time, each group will give a short pitch on their mini lesson or activity and we will provide feedback to the group about what works and what could deepen the impact of their lesson. This will be called their "glow" and their "grow."

The participants exit ticket will be to write a short reflection on an exit slip on the prompts:

"How can a garden be used to teach about climate change?"

"What are some of the challenges associated with teaching about climate change?"

"Why is it important for educators to be climate-literate?"

Assessment (that matches with the original Objectives)

Participants will be assessed based on their engagement in group discussion, their produced mini lesson, and their exit ticket.

Explanation of How You Have Address ALL 4 Learners—Use 4MAT Theory to Explain

Type 1: Insight

Insight learners will appreciate the garden walk and observation which invites direct sensory experience and encourages personal reflection on environmental change. They will also appreciate group discussion and think-pair-share activity as these link content to participants' values and lived experiences as well as allowing learned to explore meaning and social connection

Type 2: Analytic

This lesson is suited to the analytic learning style as it includes guided exploration of the NGSS and the CA state standards websites that lets these learners dive into factual, research-based content. The mini-lesson on NGSS's 3 dimensions and discussion of Assembly Bill 285 also provides a clear conceptual structure and legislative context.

Type 3: Common Sense

Common sense learners will appreciate identifying a real garden feature and linking it to an NGSS-aligned concept and grade level. Designing a mini-lesson plan with a partner allows for immediate application of what they're learning, supporting these learners' desire to know how to apply what they learn in practical, hands-on ways.

Type 4: Dynamic

This lesson is suited to the dynamic learning style as the lesson pitch activity allows for personal creativity and innovation in designing climate-focused instruction. The feedback section also encourages reflective iteration and open-ended idea sharing.

Lesson #4 Reflection:

After teaching this lesson, I think I felt a huge sense of relief and accomplishment. This was the lesson I was most worried about because it was different from all of the other ones I had planned and was in a different location with a different audience. However, I feel like it went really well and everyone was very receptive to the content and activities. I also feel relieved that it was the last lesson I had to plan and really do a lot of the heavy lifting prep-work for. What went particularly well was everyone doing the mini lesson handout in pairs. I hadn't gone through the worksheet that I had made myself to see if it was something that was doable or would be fun and engaging. It was really nice to be able to hear the conversations that were happening around me and hear how much everyone was really getting into the questions. It was also cool to see some mix-up in the pairings among the Garden Girls and see people working together that don't normally do.

I also really appreciated some of the responses that people said for some of the discussion questions, as they weren't answers that I had thought of myself. In response to the questions about some of the effects of climate change that might appear in our garden, folks said things like how cliff erosion may result in there being a need to build more housing that may be built on the land the garden is on and how warming temperatures may change what can be grown in the garden.

I think one thing I would do differently if I were to teach this lesson again would be to go more in depth about how to actually read the NGSS standards and how the tables are organized. It seemed like a few of the participants were a bit confused and overwhelmed by the three packets of tables (which I understand and acknowledge because it's a lot of information!). I also think it may be helpful to do this lesson half inside and half outside to be able to have the participants have more of a formal classroom setting to be able to do the group work. I might also recommend having more time for everyone to digest all of the information about the standards and spending more time highlighting the specific standards that have to do with climate change.

I would say that yes the participants attained the objectives I set out for this lesson. I think it was particularly helpful for those who had never been exposed to the NGSS standards before to get some practice with them and based on the responses in the group and paired discussions, it seemed as though everyone could recognize the power of using a garden like ours for place-based learning that is aligned with standard for teaching climate change. There was not enough time to get through to the exit ticket which was the primary way that I was going to assess participants' knowledge, however each group was engaged throughout the lesson and produced well rounded mini lesson/activity plans which showed to me that they were grasping the material and digesting its significance.

ENVS 127B

JOURNAL

This belongs to: Danielle Mitchell

Sit Spot Activity #1

Name: Danielle Mitchell
Location: North Campus (beach/outlook)
Date & time: May 5, 2025 ; 5:00pm

I notice the trees swaying with the cool breeze and the pelicans & gulls flying off towards the sea. I hear the waves crashing onto the sand and the buzzing of bees near the colorful wild flowers. The small pod of dolphins circling in the water astonishes me. I would love to see them jump again towards the setting sun

Sit Spot Activity #2

Student of choice: 2nd grader
Location: Forests
Date & time:

I see very tall trees with many leaves. Some leaves are green, while others are red, orange and yellow. Why is that? There is also a little squirl burying a seed from one of the trees, is he gardening like I do? Or is he just saving a snack for later? I hear many birds, but some sound different. I wonder if they understand each other?

ENV S 127B

JOURNAL

This belongs to: Olivia Hunter

Sit Spot Activity #1

Name: Olivia
Location: ED 4211
Date & time: 5/6 5:20pm

location: beach

notice - sparkles on water
sensations - hear waves, see people surfing, smell salty air, feel sand
admire - people relaxing on their own
astonished by - dolphins
see again - sunset

5 it Spot Activity # 2

Student of choice: 4th grader
Location: School
Date & time:

notice it's almost recess
hear friends, see homework,
feel desk, smell crayons
astonished by math lesson

ENVS 127B

JOURNAL

This belongs to: Karin

Sit Spot #1

Name: KARIN
Location: my yard
Date & time: afternoon

Lots of little birds (tits? kinglets? warbler?) eating the insects around our oak tree, I hear their chirping. A bit of citrus scent is in the air, it feels pleasently warm. I admire our oaktree and how it filters and transforms the sunlite into little gems of blink. I'd like to see an Oriole (?) again, and our hummingbirds.

Sit Spot Activity #2

Student of choice: Abel, age 12
Location: fo soccer field
Date & time: early evening

imagines running barefoot over grass, maybe feeling some twigs or burs pinching his soles
he wants to climb the tree, feeling the rough bark, smelling the sap, hearing the insects fly and the birds in the leaves; feeling a sense of freedom up in the branches, and a sense of calm looking down and far

Sit Spot Activity #1

Name: Danielle Mitchell
Location: North Campus (beach/outlook)
Date & time: May 5, 2025 ; 5:00pm

I notice the trees swaying with the cool breeze and the pelicans & gulls flying off towards the sea. I hear the waves crashing onto the sand and the buzzing of bees near the colorful wild flowers. The small pod of dolphins circling in the water astonishes me. I would love to see them jump again towards the setting sun

Workshop #2 - Bringing climate science into the classroom

Journaling - "Why should students learn about climate change?"

So they know how to take action in the future, & they can appreciate & learn how to take care of their environment.

Practice with NGSS

- Read standards + laws
- Pick grade band
- Identify what the standards/laws say, where this fits into grade band of choice, what opportunities or challenges they foresee in how this legislation will play out in real time in the classroom
- Questions to guide exploration:
    - What's emphasized?
    - What does the law say? What are the expectations?
    - What would this look like in class and how might this change conversations or curriculum?
- We will come back together and share our main takeaways as a group!

Elementary school — LS1.D: Information Processing

- how animals use their brain, memory, etc.
- can help emphasize students' sense of self & understand that animals are thinking creatures too

Classroom Connection

- How should educators' support students mental health while they learn about climate change?
- What emotions, thoughts, and feelings do you anticipate would arise in your students from talking about climate change?
- How could teaching about climate change be combined with nature connection and environmental education in schools?

1. Let them know that their feelings are normal, provide resources
2. Anxiety, sadness, anger, determination
3. Emphasize the importance of nature, but point out that it's also in danger & needs our help

Exit Ticket

"One new thing I understand about NGSS and climate education laws is…"
"One way I can help my students become more climate literate is…"
"I now feel ____ (1–5) prepared to incorporate climate education into my teaching."

① that they are a crucial part of science education

② incorporating it in small bits over many lessons

③ 5!

Workshop #3 - Integrating Environmental Education & Climate Science Into a Science Lesson

Discussion

- What local environmental change have you noticed in your hometown or in the UCSB/IV community?
- Why do you think it's important to teach climate change in K–12 settings? What's hard about it?

① Cliffs falling in IV

② Important for future climate justice, but can be a heavy, depressing topic for kids

Climate Justice Education Framework

- Research a climate/environmental issue in SB County
- Select 1-2 elements of the Climate Justice Education Framework that relate to your chosen issue
- Identify NGSS Disciplinary Core Idea that relates to your issue and chosen elements
- Start thinking about how can these issues and concepts be introduced to a specific grade

1. Cliffs
2. "solution- & action- focused"
3. ESS2.A- Earth Materials & Systems
4. Elementary school- how water moves sand on the beach

"How does the Climate Justice Framework help you think about teaching this issue with respect to both science content and environmental literacy?"

Helps to understand the idea of explaining the broader topic first before getting into climate change/environmental literacy.

Create a mini lesson/activity!

- Now, you will apply what you have explored to design a mini lesson or classroom activity about your chosen climate change impact at your chosen grade level. Be sure to include science content from your chosen NGSS DCI, climate justice concepts, student engagement strategies that empower and connect students to local issues, and age-appropriate instructional methods
- Questions to keep in mind:
  - How will you help students see the local impact?
  - What inquiry or hands-on activities can you include?
  - How will you integrate justice and equity

- Hands-on activity w/ sand & water
- help them understand how elements like water physically shape our earth
- teach them about how the water/ocean is affected by climate change — can make sand/earth move more.

Final Reflection

- What is one aspect of your lesson you feel excited to implement?
- What challenges do you anticipate in teaching climate justice topics?
- How has your confidence or perspective on teaching climate science evolved through these workshops?

1. A hands-on activity!
2. Misunderstanding, facilitating fear
3. Makes me feel more prepared!

Disciplinary Core Ideas in the Next Generation Science Standards (NGSS) Final Release

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
Life Science				
LS1: From Molecules to Organisms: Structures and Processes				
LS1.A: Structure and Function	• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1)	• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)	• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1) • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MSLS3-2) • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2) • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3)	• Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1) • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (secondary to HS-LS3-1) • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2) • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)
LS1.B: Growth and Development of Organisms	• Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)	• Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)	• Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4) • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4) • Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)	• In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)
LS1.C: Organization for Matter and Energy Flow in Organisms	• All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)	• Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1) • Plants acquire their material for growth chiefly from air and water. (5-LS1-1)	• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7)	• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7) • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (HS-LS1-7)
LS1.D: Information Processing	• Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs. (1-LS1-1)	• Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)	

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
LS2: Ecosystems: Interactions, Energy, and Dynamics				
LS2.A: Interdependent Relationships in Ecosystems	• Plants depend on water and light to grow. (2-LS2-1) • Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)	• The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)	• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)	• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HSLS2-2)
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems		• Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)	• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3) • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4) • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)
LS2.C: Ecosystem Dynamics, Functioning, and Resilience		• When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary to 3-LS4-4)	• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)	• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6) • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
LS2.D: Social Interactions and Group Behavior		• Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size (Note: Moved from K–2). (3-LS2-1)	• Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)	• Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HSLS2-8)
LS3: Heredity: Inheritance and Variation of Traits				
LS3.A: Inheritance of Traits	• Young animals are very much, but not exactly, like, their parents. Plants also are very much, but not exactly, like their parents. (1-LS3-1)	• Many characteristics of organisms are inherited from their parents. (3-LS3-1) • Other characteristics result from individuals' interactions with • the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2)	• Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)	• Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)
LS3.B: Variation of Traits	• Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)	• Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1) • The environment also affects the traits that an organism develops. (3-LS3-2)	• In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2) • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)	• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2) • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)
LS4: Biological Evolution: Unity and Diversity				
LS4.A: Evidence of Common Ancestry and Diversity		• Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (Note: moved from K-2) (3-LS4-1) • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (3-LS4-1)	• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1) • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)	• Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)
LS4.B: Natural Selection		• Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)	• Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4) • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)	• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3) • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
LS4.C: Adaptation		• For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3)	• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)	• Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2) • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4) • Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5),(HS-LS4-6) • Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)
LS4.D: Biodiversity and Humans	• There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)	• Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4)		• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HSLS2-7) • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7) (HS-LS4-6)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
Earth and Space Science				
ESS1: Earth's Place in the Universe				
ESS1.A: The Universe and Its Stars	• Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)	• The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)	• Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1) • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)	• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HSESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1- 2),(HS-ESS1-3)
ESS1.B: Earth and the Solar System	• Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)	• The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MSESS1-3) • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1) • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)	• Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)
ESS1.C: The History of Planet Earth	• Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1)	• Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)	• The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE) (secondary to MS-ESS2-3)	• Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5) • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
ESS2: Earth's Systems				
ESS2.A: Earth Materials and Systems	• Wind and water can change the shape of the land. (2-ESS2-1)	• Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1) • Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)	• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1) • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HSESS2-1),(HS-ESS2-2) • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)
ESS2.B: Plate Tectonics and Large-Scale System Interactions	• Maps show where things are located. One can map the shapes and kinds of land and water in any area. (2-ESS2-2)	• The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)	• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-3)	• The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3) • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (HS-ESS2-1) (secondary to HS-ESS1-5)
ESS2.C: The Roles of Water in Earth's Surface Processes	• Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (2-ESS2-3)	• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MSESS2-5) • Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4) • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6) • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
ESS2.D: Weather and Climate	• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K-ESS2-1)	• Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1) • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)	• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) • Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5) • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)	• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4) • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4) • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HSESS3-6)
ESS2.E: Biogeology	• Plants and animals can change their environment. (KESS2-2)	• Living things affect the physical characteristics of their regions. (4-ESS2-1)		• The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
ESS3: Earth and Human Activity				
ESS3.A: Natural Resources	• Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3-1)	• Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)	• Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)	• Resource availability has guided the development of human society. (HS-ESS3-1) • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)
ESS3.B: Natural Hazards	• Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (K-ESS3-2)	• A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) (4-ESS3-2.)	• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	• Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)
ESS3.C: Human Impacts on Earth Systems	• Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (K-ESS3-3) (secondary to K-ESS2-2)	• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)	• The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)
ESS3.D: Global Climate Change		•	• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
Physical Science				
PS1: Matter and Its Interactions				
PS1.A: Structure and Properties of Matter	• Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1-1) • Different properties are suited to different purposes. (2-PS1-2),(2-PS1-3) • A great variety of objects can be built up from a small set of pieces. (2-PS1-3)	• Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model shows that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects. (5-PS1-1) • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5-PS1-2) • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5-PS1-3)	• Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2), (MS-PS1-3) • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1) • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)	• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6) • Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)
PS1.B: Chemical Reactions	• Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)	• When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4) • No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.) (5-PS1-2)	• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) • The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5) • Some chemical reactions release energy, others store energy. (MS-PS1-6)	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)
PS1.C: Nuclear Processes				• Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HSPS1-8) • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-5),(secondary to HS-ESS1-6)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
PS2: Motion and Stability: Forces and Interactions				
PS2.A: Forces and Motion	• Pushes and pulls can have different strengths and directions. (KPS2-1),(K-PS2-2) • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2)	• Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1) • The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)	• For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MSPS2-2)	• Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS-PS2-2) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)
PS2.B: Types of Interactions	• When objects touch or collide, they push on one another and can change motion. (K-PS2-1)	• Objects in contact exert forces on each other. (3-PS2-1) • Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3),(3-PS2-4) • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)	• Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4) • Forces that act at a distance (electric and magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (MS-PS2-5)	• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)
S2.C: Stability and Instability in Physical Systems				• …and "electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
PS3: Energy				
PS3.A: Definitions of Energy		• The faster a given object is moving, the more energy it possesses. (4-PS3-1) • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)	• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) • A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4) • The term "heat" as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. (secondary to MS-PS1-4) • Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (secondary to MS-PS1-4)	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (HS-PS3-3) • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)
PS3.B: Conservation of Energy and Energy Transfer	• Sunlight warms Earth's surface. (K-PS3-1),(K-PS3-2)	• Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3) • Light also transfers energy from place to place. (4-PS3-2) • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)	• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)	• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) • The availability of energy limits what can occur in any system. (HS-PS3-1) • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)
PS3.C: Relationship Between Energy and Forces	• A bigger push or pull makes things go faster. (secondary to K-PS2-1)	• When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)	• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	• When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
PS3.D: Energy in Chemical Processes and Everyday Life		• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) • The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)	• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6) • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5) • Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
PS4: Waves and Their Applications in Technologies for Information Transfer				
PS4.A: Wave Properties	• Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1)	• Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave except when the water meets the beach. (Note: This grade band endpoint was moved from K–2.) (4-PS4-1) • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)	• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) • A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HSPS4-5) • [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) • Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)
PS4.B: Electromagnetic Radiation	• Objects can be seen only when light is available to illuminate them. Some objects give off their own light. (1-PS4-2) • Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)	• An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)	• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2) • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2) • However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)	• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.(HS-PS4-4) • Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)
PS4.C: Information Technologies and Instrumentation	• People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	• Digitized information transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)	• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	• Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Topic	Primary School (Grades K-2)	Elementary School (Grades 3-5)	Middle School (Grades 6-8)	High School (Grades 9-12)
Engineering, Technology, and the Application of Science				
ETS1: Engineering Design				
ETS1.A: Defining and Delimiting an Engineering Problem	• A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1-1) (secondary to KPS2-2) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) (secondary to K-ESS3-2) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) (secondary to 4-PS3-4)	• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (MS-ETS1-1) (secondary to MS-PS3-3)	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) (secondary to HS-PS2-3) (secondary to HS-PS3-3) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)
ETS1.B: Developing Possible Solutions	• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-1) (secondary to K-ESS3-3) (secondary to 2-LS2-2)	• Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) • Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)	• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) (secondary to MS-PS1-6) • There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. MS-ETS1-2), (MS-ETS1-3) (secondary to MS-PS3-3) (secondary to MS-LS2-5) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4)	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7) (secondary to HS-LS4-6) (secondary to HS-ESS3-2),(secondary HS-ESS3-4) (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) (secondary to HS-LS4-6)
ETS1.C: Optimizing the Design Solution	• Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-1) (secondary to 2-ESS2-1)	• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) (secondary to 4-PS4-3)	• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. (MS-ETS1-3 (secondary to MS-PS1-6) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MSETS1-4) (secondary to MS-PS1-6)	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HSETS1- • 2) (secondary to HS-PS1-6) (secondary to HS-PS2-3)

Science & Engineering Practices in *Next Generation Science Standards*

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Asking Questions and Defining Problems: A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested.	Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.	Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, clarify arguments and models.	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
• Ask questions based on observations to find more information about the natural and/or designed world(s).	• Ask questions about what would happen if a variable is changed.	• Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. • Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument. • Ask questions to determine relationships between independent and dependent variables and relationships in models. • Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	• Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. • Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. • Ask questions to clarify and refine a model, an explanation, or an engineering problem.
• Ask and/or identify questions that can be answered by an investigation.	• Identify scientific (testable) and non-scientific (non-testable) questions. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	• Ask questions that require sufficient and appropriate empirical evidence to answer. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	• Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
		• Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.	• Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.
• Define a simple problem that can be solved through the development of a new or improved object or tool.	• Use prior knowledge to describe problems that can be solved. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	• Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	• Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

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Science and Engineering Practices

Developing and Using Models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
• Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences.	• Identify limitations of models.	• Evaluate limitations of a model for a proposed object or tool.	• Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability.
• Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	• Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena.	• Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms.	• Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
• Develop a simple model based on evidence to represent a proposed object or tool.	• Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	• Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	• Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

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Science and Engineering Practices

Planning and Carrying Out Investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.	Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
• With guidance, plan and conduct an investigation in collaboration with peers (for K). • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	• Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	• Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
• Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.	• Evaluate appropriate methods and/or tools for collecting data.	• Evaluate the accuracy of various methods for collecting data.	• Select appropriate tools to collect, record, analyze, and evaluate data.
• Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. • Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. • Make predictions based on prior experiences.	• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. • Make predictions about what would happen if a variable changes. • Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.	• Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. • Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.	• Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

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Science and Engineering Practices

Analyzing and Interpreting Data: Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis. Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.	Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.	Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
• Record information (observations, thoughts, and ideas). • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events).	• Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.	• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Distinguish between causal and correlational relationships in data. • Analyze and interpret data to provide evidence for phenomena.	• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
	• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.	• Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.	• Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
		• Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	• Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
	• Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.	• Analyze and interpret data to determine similarities and differences in findings.	• Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
• Analyze data from tests of an object or tool to determine if it works as intended.	• Analyze data to refine a problem statement or the design of a proposed object, tool, or process. • Use data to evaluate and refine design solutions.	• Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	• Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

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Science and Engineering Practices

Using Mathematics and Computational Thinking: In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s).	Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
		• Decide when to use qualitative vs. quantitative data.	• Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
• Use counting and numbers to identify and describe patterns in the natural and designed world(s).	• Organize simple data sets to reveal patterns that suggest relationships.	• Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.	• Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
• Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.	• Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.	• Use mathematical representations to describe and/or support scientific conclusions and design solutions.	• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
• Use quantitative data to compare two alternative solutions to a problem.	• Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	• Create algorithms (a series of ordered steps) to solve a problem. • Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. • Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	• Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

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Science and Engineering Practices

Constructing Explanations and Designing Solutions: The end-products of science are explanations and the end-products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.	Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
• Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	• Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).	• Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations.	• Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
	• Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	• Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
	• Identify the evidence that supports particular points in an explanation.	• Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	• Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
• Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. • Generate and/or compare multiple solutions to a problem.	• Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	• Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	• Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

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Science and Engineering Practices

Engaging in Argument from Evidence: Argumentation is the process by which evidence-based conclusions and solutions are reached. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
• Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations.	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.	• Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.	• Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
• Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.	• Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model.by citing relevant evidence and posing specific questions.	• Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	• Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
• Construct an argument with evidence to support a claim.	• Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect.	• Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	• Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	• Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	• Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

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Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information: Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs.

K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.	Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.	Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.
• Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).	• Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.	• Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
• Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.	• Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.	• Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	• Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
• Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim.	• Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.	• Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. • Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.	• Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
• Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.	• Communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.	• • Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	• Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

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Matrix of Crosscutting Concepts in NGSS

NGSS@NSTA STEM STARTS HERE

K-2	3-5	6-8	9-12
Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.			
• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be used to make predictions. • Patterns can be used as evidence to support an explanation.	• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.			
• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.			
• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length.	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Developed by NSTA using information from Appendix G of the *Next Generation Science Standards* © 2011, 2012, 2013 Achieve, Inc.

Adapted from: National Research Council (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academy Press. Chapter 4: Crosscutting Concepts.

K-2	3-5	6-8	9-12
Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.			
• Objects and organisms can be described in terms of their parts. • Systems in the natural and designed world have parts that work together.	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. • A system can be described in terms of its components and their interactions.	• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation: Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.			
• Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	• Matter is made of particles. • Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. • Energy can be transferred in various ways and between objects.	• Matter is conserved because atoms are conserved in physical and chemical processes. • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). • The transfer of energy can be tracked as energy flows through a designed or natural system.	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
Structure and Function: The way an object is shaped or structured determines many of its properties and functions.			
• The shape and stability of structures of natural and designed objects are related to their function(s).	• Different materials have different substructures, which can sometimes be observed. • Substructures have shapes and parts that serve functions	• Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.			
• Some things stay the same while other things change. • Things may change slowly or rapidly.	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.	• Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	• Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. • Systems can be designed for greater or lesser stability.

Nallely, Yahaira & Morgan

Garden-Based Mini-Lesson Plan Template

Use this template to outline a short, NGSS-aligned activity or mini-lesson that incorporates climate change concepts and takes place in our garden!

Title of Lesson or Activity:

Erosion control

Grade Band:

K-2

Local Phenomenon or Garden Observation Focus:
What observable aspect of the garden will students investigate or engage with?

Students will ~~construct~~ use garden materials to construct structures to stand erosion.

Relevant NGSS Connections

Disciplinary Core Idea (DCI): Earth Materials and Systems

Science & Engineering Practice (SEP): Ask or identify questions that can be answered by an investigation.

Crosscutting Concept (CCC): Cause & Effect mechanism and Prediction

Climate Science Connection
How does the activity increase students' awareness about climate change?

It touches on erosion which touches on sea level rise & how ecosystems are affected.

Lesson Objectives - Cognitive & Affective:
What do you want for students to get out of this lesson the most?

Gain awareness on the effects of erosion day to day.

Feeling curious about solutions to sea level rise. Have fun constructing structures!

Lesson/Activity Overview:
Give a short summary of what students would be doing

Students will make a structure from garden materials where they will see how permeability and vegetation buffer can help with erosion.

Guiding Questions:
What driving or inquiry-based question will focus student thinking?

What materials or plants can help prevent erosion?

Did your structure help prevent erosion?

Student Engagement & Empowerment:
How will this activity promote student agency, hope, or local action?

Students will be more aware on how ~~the~~ ~~erosion~~ erosion affects their community & solutions

Students will understand actions they can take to make their ecosystem more permeable.

Natalie & Liv

Garden-Based Mini-Lesson Plan Template

Use this template to outline a short, NGSS-aligned activity or mini-lesson that incorporates climate change concepts and takes place in our garden!

Title of Lesson or Activity:

Grade Band:

Grade 6-8

Local Phenomenon or Garden Observation Focus:
What observable aspect of the garden will students investigate or engage with?
Students will investigate how increased weather extremes will affect development. Specifically ~~what~~ how this would affect the garden.

Relevant NGSS Connections (MS-ESS3-3)
Disciplinary Core Idea (DCI): Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts for different living things
Science & Engineering Practice (SEP): Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions
Crosscutting Concept (CCC): phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability

Climate Science Connection
How does the activity increase students' awareness about climate change?
The activity will increase students' awareness about climate change by introducing direct and indirect causes. It will explain the direct impact of climate change on the bluffs and the indirect impact on the garden.

Lesson Objectives - Cognitive & Affective:
What do you want for students to get out of this lesson the most?
cognitive: Students will use local examples to explain the connection between weather patterns and local development. They will also engage in group discussion to come up with possible solutions to support the garden.
Affective: students will gain awareness about the

Lesson/Activity Overview:
Give a short summary of what students would be doing

Guiding Questions:
What driving or inquiry-based question will focus student thinking?

Student Engagement & Empowerment:
How will this activity promote student agency, hope, or local action?

Kelsey & Bridget

Garden-Based Mini-Lesson Plan Template

Use this template to outline a short, NGSS-aligned activity or mini-lesson that incorporates climate change concepts and takes place in our garden!

Title of Lesson or Activity: Conponents & creating a garden

Grade Band: 6th grade

Local Phenomenon or Garden Observation Focus:
What observable aspect of the garden will students investigate or engage with?
Students will engage with the growth of the plants and decomposers within the context of soil

Relevant NGSS Connections
Disciplinary Core Idea (DCI): food webs are models that demostrate how matter and energy is transferred between producers, consumers & decomposers as the three groups interact within an ecosystem
Science & Engineering Practice (SEP): collecting data about the performance of a proposed process or system under a range of conditions
ask questions, Define a design
Crosscutting Concept (CCC): cause & effect relationships may be used to predict phenomena in natural or designed systems

Climate Science Connection
How does the activity increase students' awareness about climate change?
It brings awarness to the students about the cause & effect the changing weather has on the garden. different weather patterns affect the gardens as a out come the students may have to water more or less

Lesson Objectives - Cognitive & Affective:
What do you want for students to get out of this lesson the most?

Students will be able to identify how much to water based on what season it is and refect this knowledge to climate

- Students will have a better understanding of food webs within garden ecosystems
- Students will identify a consumer, producer, decomposer in the garden

Lesson/Activity Overview:
Give a short summary of what students would be doing

Students will participate in building a school garden started w/ adding soil & fertilizer → learning as they go students will learn what plants go together & learn how & when to water. They will gain better understanding of what animals are within a healthy garden ecosystem

Guiding Questions:
What driving or inquiry-based question will focus student thinking?

what organisms are producers? which are consumers? which are decomposers?

why is it important to add compost to the garden

Student Engagement & Empowerment:
How will this activity promote student agency, hope, or local action?

It will inspire students to eat locally & healthy

promote increased mental health from being outdoors

Lakshmi & Ruby

Garden-Based Mini-Lesson Plan Template

Use this template to outline a short, NGSS-aligned activity or mini-lesson that incorporates climate change concepts and takes place in our garden!

Title of Lesson or Activity:

The Birds & the Bees

Grade Band:

Elementary School (3-5)

Local Phenomenon or Garden Observation Focus:
What observable aspect of the garden will students investigate or engage with?

Lesson on pollination / pollinators in the West Campus gardens (family housing). OR Botanical Garden!

Relevant NGSS Connections
Disciplinary Core Idea (DCI):

Living things affect the physical characteristics of a region.

Science & Engineering Practice (SEP): Condensed Practices: "what would happen if a variable was changed" & observe of the bee — climate change why would happen?

Crosscutting Concept (CCC): System & System Models: "described in terms of its components & interactions" & focus on botany — flower anatomy

Climate Science Connection
How does the activity increase students' awareness about climate change?

If there's no bees due to their extinction, how would this affect pollination / plants?

Lesson Objectives - Cognitive & Affective:
What do you want for students to get out of this lesson the most?

1. Learn about pollinators
2. Species interactions

Lesson/Activity Overview:
Give a short summary of what students would be doing

1. Have students pick a plant they like
2. Have them watch what pollinators come by!

Guiding Questions:
What driving or inquiry-based question will focus student thinking?

1. What type of pollinators did you observe?
2. Why do you think they're doing that?
3. What would happen if they were gone?

Student Engagement & Empowerment:
How will this activity promote student agency, hope, or local action?

- importance of bees & pollinators, more inclined to protect them!
- confidence engaging w/ local environment!
- Have cool fact to share / greater connection to plant they observed!

Mari & Anna

Garden-Based Mini-Lesson Plan Template

Use this template to outline a short, NGSS-aligned activity or mini-lesson that incorporates climate change concepts and takes place in our garden!

Title of Lesson or Activity:

Climate change impacts on gardens + vegetation

Grade Band:

8th grade

Local Phenomenon or Garden Observation Focus:
What observable aspect of the garden will students investigate or engage with?

- weeds (non-natives)
- garden plants / natives

Relevant NGSS Connections
Disciplinary Core Idea (DCI):

Earths systems, weather & climate

Science & Engineering Practice (SEP):

planning + carrying out investigations

Crosscutting Concept (CCC):

cause & effect, stability + change

Climate Science Connection
How does the activity increase students' awareness about climate change?

students will understand tangible and visible outcomes

Lesson Objectives - Cognitive & Affective:
What do you want for students to get out of this lesson the most?

Understanding human actions + consequences on the planet

Lesson/Activity Overview:
Give a short summary of what students would be doing

going around to different garden areas and counting weeds vs planted garden plants & natives

Guiding Questions:
What driving or inquiry-based question will focus student thinking?

Do you think this is a pattern that will increase with climate change?

Student Engagement & Empowerment:
How will this activity promote student agency, hope, or local action?

Awareness, changing actions and sharing with others.

Env S 127B - Environmental Education Project Proposal

Final Reflection

Brainstorming, designing, planning, implementing, and teaching this project has been one of the most difficult, challenging, and rewarding learning experiences I have had in my time at school. I think coming up with and writing lesson plans and teaching lessons in only a ten week time frame was a super challenging and in-depth crash course in teaching environmental education. I personally have learned a lot more about the way I like to do work and that I am more creative and driven than I thought I was when it comes to getting a project like this done. I also feel like I have grown in my confidence to teach the material and topic I chose to design a unit of instruction on and also in my ability to execute a lesson based on the plan I wrote.

One of the biggest challenges for me was figuring out what exactly it was I wanted to teach and what each lesson would be. For me it was easier to decide who I was going to teach because I was able to use my role as co-president to incorporate my project and lessons into the CalTeach Together Club meetings in the form of workshops. After about two weeks of thinking and brainstorming I was able to settle on teaching about integrating environmental education and climate science with Next Generation Science Standards (NGSS) in classroom settings and how future educators can become better prepared to teach about climate change. My thought process was that I wanted to combine all that I know as an Environmental Studies major and all that I have learned from taking several environmental education courses with the skills and knowledge of the members of the CalTeach Together Club, most of whom want to become teachers.

I had a bit of trouble figuring out how to break up the lessons and how to make them connect while also introducing new information. The lessons I came up with were for how to develop personal nature connection as teachers, how to bring climate science into the classroom, how to integrate environmental education and climate science into a science lesson, and finally how to combine outdoor and place-based learning at the UCSB Greenhouse Garden Project with Next Generation Science Standards. I also decided to use the 5E model for what each lesson would consist of rather than the Natural Learning Cycle as I feel as though it made more sense of my lesson plans; I also have experience with using this model from other education courses and felt more comfortable using it to design lesson plans.

I originally decided to teach three lessons and ended up adding a fourth lesson that was a condensed version of the second and third lessons I designed to teach to my peers in 127B. My plans for teaching and for what the lessons would consist of changed a bit from my original project proposal. For example, I had written that for the second lesson I was planning on having participants learn about how to adapt teaching methods and content when it comes to having different students learn about climate change as well as having them research a local climate change issue and will give a short presentation acting out as teachers for their age group of

choice. This got tweaked a bit and I ended up for the second lesson planning to have participants get some practice with NGSS and thinking about how standards can be used to design lessons and how those lessons can be adapted based on what the standard says for each specific grade band. I also adapted the third lesson to rather than telling participants to use coastal wetlands as the subject of their mini lesson or activity that they create, I gave them the freedom to instead use a local climate change issue of their choice.

In terms of meeting the Tbilisi Declaration Objectives, I feel that I was able to achieve this with my lesson plans. For awareness, I was able to help the members of the club acquire and build upon a consciousness and sensitivity to the environment and its problems by teaching them about local issues of climate change as well as the importance of environmental education. I was able to expand the knowledge of my participants by teaching them about different methods for integrating environmental education into the classroom as well as all of the resources for teaching about climate change that exist already, such as Ten Strands, C-Justice, and the Climate Justice Education Framework. I was able to help my participants acquire a set of values and feelings of concern for the environment and for teaching others by asking them to reflect on their own connection to nature and what motivates them to teach. I think that helping my participants acquire the skills for identifying and solving environmental problems was achieved the most from my lessons because of all of the practice that the participants got with the Next Generation Science Standards and using them to design mini lessons. For providing opportunities for participants to be actively involved at all levels in working toward resolution of environmental problems, I don't think my lessons achieved this fully as they were more focused on what participants could do in the future career and not so much now in their life.

For the guiding principles from the Blueprint for Environmental Literacy I was able to provide equity of access by having these lessons available to all members of the CalTeach Together Club of which all undergraduate students are welcome to participate in. These lessons are also sustainable because they can be sustained and adapted over time as well as being able to be taught to larger groups and incorporate multiple sources for teaching resources. In terms of cultural relevance and competence, these lessons were able to get participants thinking about how to use their knowledge and experiences to create meaningful and grade-appropriate lessons for their students and incorporated a variety of learning experiences by having participants go through many different activities, worksheets, journaling prompts, group discussions, and hands-on activities.

For meeting the needs of all of my participants, I made sure to actively include everyone in group discussions and activities and to reiterate all opinions that were expressed. I also made sure that my lessons would be appreciated by all of the 4Mat learning styles and that insight, analytic, common sense, and dynamic learners would all get something out of each lesson.

In reflecting on teaching the first lesson I feel like it went well and had a strong start due to the relaxed atmosphere of having a small group since only a handful of club members showed

up. Olivia and Dani were engaged and enthusiastic, showing interest in using the activities in their own teaching, especially the journaling activity. In discussing what environmental education is, the participants defined it broadly, and included climate justice, environmental impacts, and the importance of local awareness. They also emphasized the need to reduce student reliance on technology and to use creativity and imagination in teaching, highlighted the need to reconnect students with the real environment, and stressed the power of imagination in fostering change. For this lesson I had to adapt a few times by asking spontaneous questions and responding to the group's energy. The second lesson came with scheduling challenges and ended up being taught to only one participant, Olivia. Despite this the lesson went well and was combined with the third lesson. The one-on-one format allowed for deeper discussion and personalized engagement. Journaling, discussion questions, and independent work, particularly reviewing NGSS standards were effective for expanding Olivia's understanding. She had limited prior experience with climate change education, and gained both content knowledge and practical ideas for integrating climate science into her future teaching. This lesson incorporated an exit ticket to check for understanding and helped confirm Olivia's positive response.

The third lesson was taught right after the second lesson and shared the same challenge of having only one participant but the overall experience felt successful. A highlight was the mini-lesson activity, where Olivia created a thoughtful, age-appropriate lesson on local cliff erosion in Isla Vista, and connected it to climate science and NGSS standards. Using online worksheets instead of paper journals like in the first lesson worked well and made the instructions clearer. This lesson would have been stronger with more participants as it would allow for more collaboration and peer feedback. In reflecting on what could have been done differently, teaching the lesson in a real-world, place-based setting, such as the bluffs along the beach, could enhance relevance and impact on the participants. A final reflection allowed me to see how Olivia felt more equipped to teach climate change to younger students and appreciated the importance of addressing the emotional dimensions of the topic; her final reflection and discussion demonstrated clear understanding and growth, serving as a strong form of assessment.

The fourth lesson was a little different than the other three and brought a strong sense of relief and accomplishment, especially since it had a different format, audience, and location. Despite initial concerns, the session went well. My peers who were participating were engaged, and the mini-lesson handout activity worked successfully in pairs. It was rewarding to hear thoughtful discussions and see participants collaborate in new ways. Participants gave insightful responses during discussions, such as how climate change might affect the garden through cliff erosion or shifting growing conditions. One area for improvement is providing clearer guidance on reading and understanding NGSS standards, as some found the materials overwhelming. Splitting the lesson between indoor and outdoor settings and allowing more time for digesting the standards might also enhance the experience. Although there wasn't time for the planned exit ticket assessment, the active participation, strong discussions, and thoughtful mini-lessons indicated that participants met the lesson objectives. The workshop helped deepen their

understanding of NGSS and the value of using gardens for place-based climate education. The chosen assessments did a good job to evaluate the effectiveness of the lessons and how participants were doing during and after the lessons. The assessments I used included checking for understanding during group discussions, journaling activities, worksheets, exit tickets, reflections, and general engagement and participation during the lesson.

Timestamp	Email Address	What is one thing you learned from these workshops that you did not know previously from your classes and lived experiences?	What would you change about these workshops? What could be done better?	What was your favorite activity or topic that we discussed?	What is one take away from these workshops that you feel like will help you in your future role/s as a teacher or educator?
6/1/2025 18:07:04	lakshmigarcia@ucsb.edu	I loved looking through the curriculum requirements and the worksheet you created!	Nothing! I liked it a lot!	I loved the worksheet and sharing outloud.	Definitely how we integrate state standards into every day lessons.
6/1/2025 18:28:10	lewin@es.ucsb.edu	A new way of presenting the NGSS to a diverse audience--some with very little exposure to NGSS and others with much more experience with NGSS. Maddi's teaching strategies--from discussion to lecture to individual exploration to "think-pair-shares to collaborative lesson planning all served the students well in being successful in starting to create a meaningful environmentally educational lesson that integrated NGSS with climate education.	Of course, with more time and more meetings, Maddi will be able to more deeply address her objectives. However, with the time she had, she did a great job!	How to find standards related to climate change education at all grade levels.	That the NGSS can be presented to teachers in ways that does not feel overwhelming or too difficult to implement in their lesson plans!
6/1/2025 18:36:52	marianavillalovoz@ucsb.edu	I did not connect climate change to real changes in community, specifically gardens.	I believe these workshops are very well done and I enjoyed being a part of it!	Climate change in relation to gardens	The science standards allowed me a deeper insight into teaching, and I believe they would better my knowledge as an educator.
6/2/2025 21:23:39	rubywedbush@ucsb.edu	I learned about the standards	I wouldn't change anything	I liked the worksheet we did	I think knowing how to use the standards will help me
6/3/2025 11:35:16	kelseymatthies@gmail.com	I learned how to make a lesson using the science guidlines!	I liked everything	I liked making the lesson plan! it was fun and engaging	knowing that science is always applied! even in the simplist ways
6/3/2025 14:58:01	daniellemitchell@ucsb.edu	Something that I learned from these workshops that I didn't know previously was the different possibilities and ways of teaching environmental education that provide students with interactive opportunities.	I think that it would be a great idea to hold these workshops in an outside setting to really draw on the aspect of connecting ourselves back to nature.	My favorite part was the journaling; most of the time, life moves too quickly for us to stop and reflect on the value of nature and how deeply it is intertwined in our lives. Hence, the journaling activity prompted me to reflect on how much I value nature.	I think that the journaling activity would be a great takeaway from this workshop because it can be applied to classes other than science, like English literacy/writing. I think it is also a great opportunity for students to be creative and have fun with the different components of nature in their own communities.